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MOSAIC, FALSE STING, AND FLAT LIMB OF APPLE[1]

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Among the abnormalities found in apple orchards in Nova Scotia, the three conditions, mosaic, false sting, and flat limb are the most conspicuous. They have been present for a number of years and though none has been considered of equal economic importance to the fungus diseases which require annual spraying to prevent damage to the crop, these three diseases have each produced losses in orchards where found. A better understanding of their etiology and transmission is necessary in order that effective steps may be taken to eliminate them from commercial orchards before further loss is sustained.

MOSAIC

Little attention was paid to the variegated condition of apple foliage found in Nova Scotia previous to 1937. Occasional observations on its occurrence have been recorded since 1926 but no study of the probable cause was attempted. Recently it became apparent in examining growers' nurseries that the variegated condition was being propagated and should be positively identified.

Symptoms

The variegated condition under study may be described as an irregular mottling of the foliage. Light yellowish to cream coloured flecks or spots of varying size and shape are interspersed in the normal green of the leaves producing very conspicuous mosaic patterns (Figures 1, 2). As the season advances there is a necrosis of the light areas in severely affected leaves resulting in a partial defoliation of the trees.

Observations and Experiments

During the winter of 1937-38 scion wood was taken from some Blenheim Orange Pippin trees which showed mottled foliage the previous season and grafts were made on several apple seedlings in the greenhouse. Distinct symptoms of leaf variegation were observed in the new scion leaves one month after grafting and later a similar leaf mottling occurred on the foliage produced from the stock itself. No such symptoms occurred on seedlings grafted with healthy scions.

Subsequent grafting and budding experiments have shown that the disease may be carried from an affected intermediate piece to both the healthy scion above and the healthy stock or root below.

The disease has been observed on a number of varieties including: King of Tompkins, Baldwin, Tolman Sweet, Blenheim Orange Pippin,

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FIGURE 1. Apple mosaic on Golden Russet.

Ribston Pippin and its red sport, Bough Sweet, McIntosh Red, Northern Spy, Gravenstein and some of its red sports, Delicious, Golden Russet, Cox Orange Pippin, Homestead, Hopa and Siberian crabs, as well as occasional seedlings. The ease with which the disease was transmitted to various seedlings and Malling type root stocks would suggest that the virus had a wide range of hosts within the genus *Malus*.

There is no doubt that the variegated condition under observation is a mosaic disease identical with that described by Bradford and Joley (1) and classified by Smith as Pyrus Virus 2.

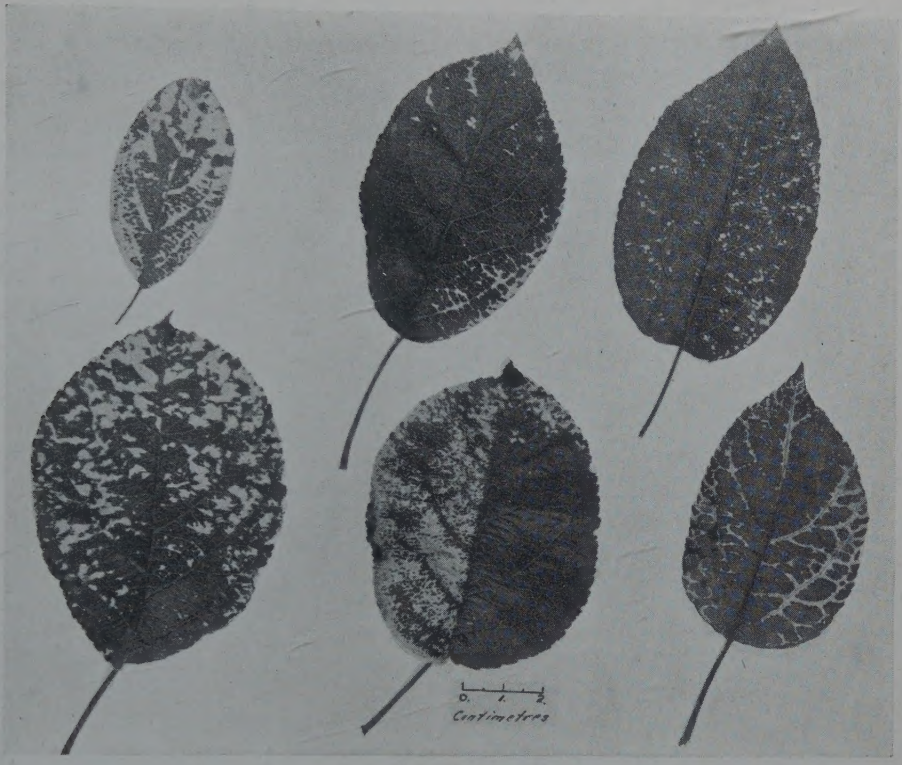

FIGURE 2. Apple mosaic on McIntosh Red showing various types of leaf mottling.

In addition to the transmission of apple mosaic by grafting, efforts were made to transmit the disease by:—

1. *Pruning wounds.* Affected leaves were crushed, then rubbed freely on a freshly cut surface of the healthy plant stem.

2. *Juice.* Leaves were crushed in a mortar and the juice drawn into fine capillary glass tubing. The tubing was then forced into a puncture in the tender growing stem, petiole, or leaf of a healthy plant.

3. *Aphids.* From 2 to 15 green apple aphids were taken from affected plants on which they had fed for at least 7 days and transferred to healthy plants.

All treated plants were kept under observation for 3 seasons. No positive symptoms of mosaic have appeared on any of these during this period. From these experiments it would appear that the transmission of apple mosaic by expressed juice or by aphid vectors is not readily obtained. An attempt to transmit lilac mosaic to apple by budding also gave negative results.

No satisfactory data have yet been obtained on the effect of mosaic on the yield of fruit. Two years' observations in an orchard of the Golden Russet variety have indicated a slightly lower yield on the affected trees. The crop was light on all trees for both seasons and the records are of doubtful significance.

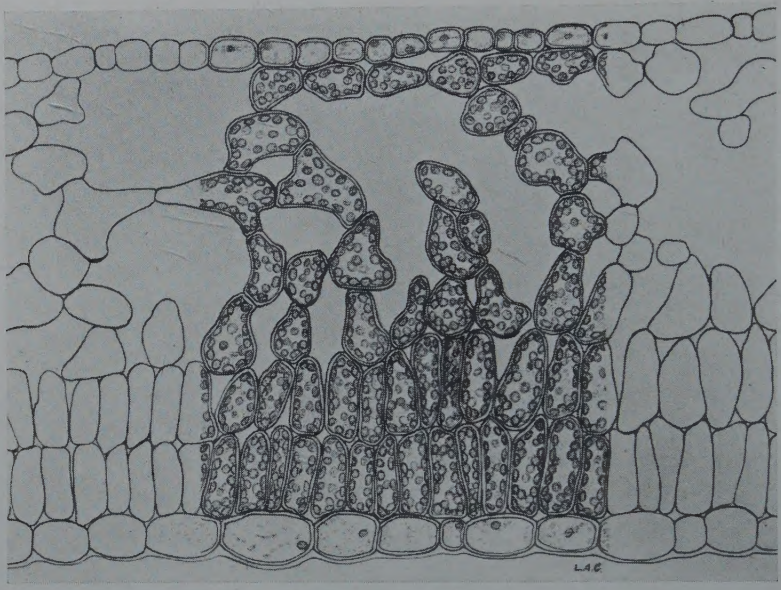

FIGURE 3. Camera lucida drawing of a cross section of a normal apple leaf, variety Blenheim.

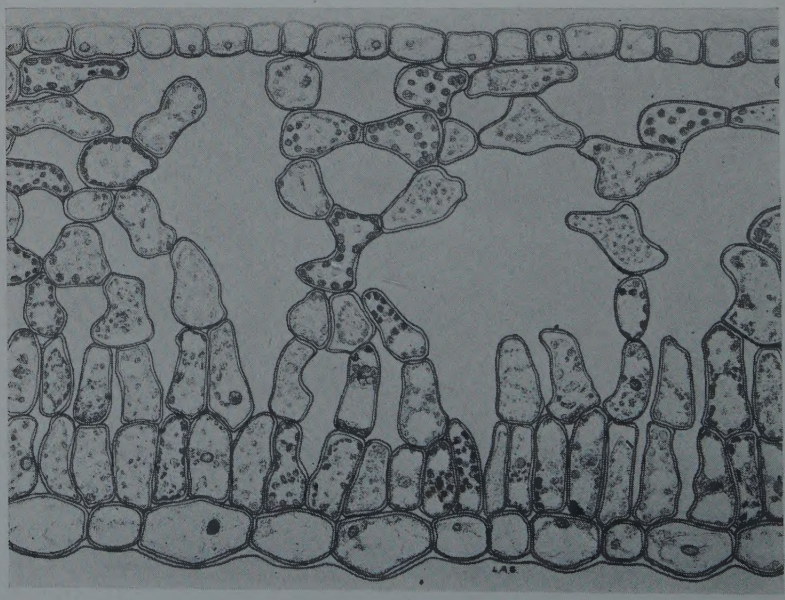

FIGURE 4. Camera lucida drawing of a chlorotic area in a leaf affected by mosaic. Compare with Figure 3.

Microscopic Features

Freehand sections of affected leaves were examined. Where the chlorosis was pronounced the chloroplasts apparently disintegrated to a hyaline granular mass. In some sections the chloroplasts and cytoplasm were brown and there was a tendency for the chloroplasts to congregate in masses at the centre or ends of the cells. In slightly affected tissue the chloroplasts were paler than in normal cells. Collapsed cells were frequently found in the spongy mesophyll.

Tests with iodine-potassium iodide solution and chloriodide of zinc showed heavy starch content in the green tissue with little or no starch in the chlorotic tissue. The guard cells of chlorotic tissue appeared to retain starch longer than other cell elements. No significant differences were found in the size or shape of palisade cells between green and chlorotic areas (Figures 3, 4).

Control

Evidence from both commercial orchards and experimental work points to exclusion and eradication as the obvious methods of preventing the further spread of the disease. The careful selection of scions from trees known to be free from mosaic and the use of those scions on known healthy stocks are the two points essential to control. While limited yield data have shown only a slight reduction in crop yield from affected trees, nevertheless the fact that mosaic is a virus disease makes it advisable to rogue nursery trees showing the disease and thus prevent a possible future loss from this source.

FALSE STING

Virus diseases of plants are identified most frequently by foliage symptoms, but the disease of apples known as false sting (5) produces its symptoms on the fruit. The foliage on trees affected with false sting shows no distinguishing characteristics.

Less than a month after bloom the small fruits have one or more depressed areas resembling the injury which follows the punctures of capsids (Figure 5). As these fruits enlarge they assume a still more distorted appearance (Figure 6). Slight cracks and russeted streaks may develop in the depressions. On the more pointed varieties of apples, such as Ben Davis, the calyx end becomes quite knurled and misshapen (Figure 7).

A microscopic examination of diseased apples reveals that the normal vascular pattern is disturbed. Main vascular bundles from the core area extend outward to the hypodermal cells adjacent to a depressed area and return to continue their normal path in the tissue. This abnormal vascular pattern is accompanied by a radial elongation of cells in the cortical region below the depressed tissue and adjacent to the distorted vascular bundles.

Affected trees have consistently borne fruit showing the symptoms of false sting. Those on which healthy scions of another variety were grafted have produced affected fruit on the scions. Orchard surveys have failed to indicate any other manner of spread of this disease except by the use of scions from an affected tree. Since the positive identification of the disease, most of the trees showing false sting in commercial orchards have

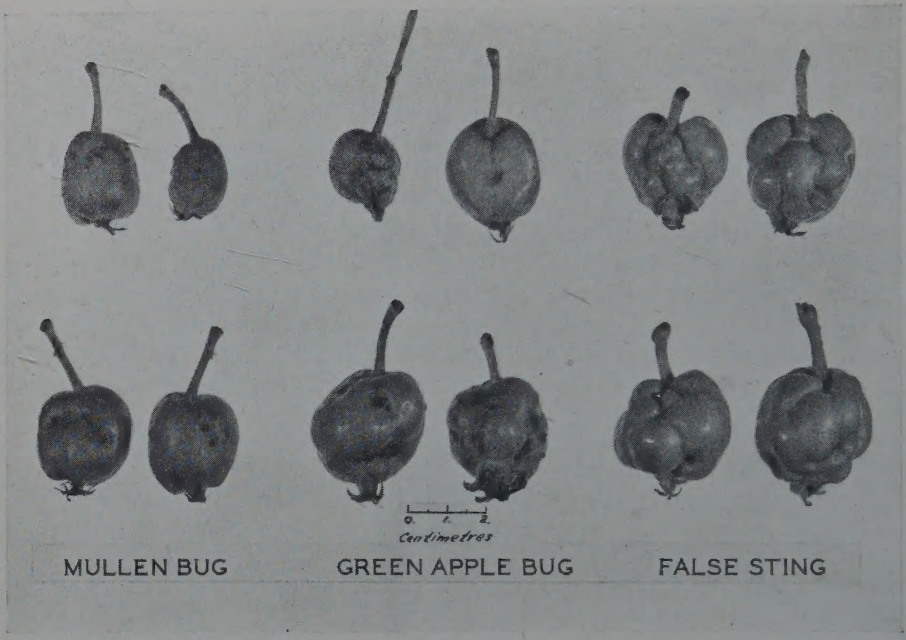

FIGURE 5. Apples showing injuries from mullein bug, green apple bug, and false sting. The varieties are not the same.

FIGURE 6. Gravenstein applies at maturity showing false sting.

FIGURE 7. Ben Davis apples at maturity showing abnormal calyx end symptom of false sting.

been rogued. The ease with which the disease is transmitted by scions makes it imperative to exercise care in the selection of scions for grafting. As no foliage or wood symptoms have been identified, it is necessary to wait until fruit is produced before false sting may be identified.

The disease has been observed on the varieties Gravenstein, Baldwin, Blenheim Orange Pippin, Ben Davis, King of Tompkins, Northern Spy, Tolman Sweet, and on McIntosh grafts.

FLAT LIMB

The Gravenstein apple has been grown in Nova Scotia for over a century and is still one of the leading varieties. Various red sports or mutants have appeared and have been extensively propagated to replace the original variety. One of the main difficulties encountered in the propagation of the Gravenstein has been the frequent appearance of a distorted stem condition giving rise to the name of "flat limb" in Nova Scotia.

History

Gravenstein flat limb has been familiar to orchardists in Nova Scotia for many years. Not only has it affected the parent variety but also the red and crimson sports. The condition has been most prevalent on

Gravenstein, although some growers claim to have observed the same or a very similar type of branch distortion on occasional trees of other varieties. Fletcher (4) was made acquainted with the "remarkable malady which attacks Gravenstein apple trees in this neighbourhood" and claimed he had "never seen nor heard tell of it in any other locality." Specimens were sent to T. J. Burrill, then at Illinois, who attempted to isolate a causal organism but without success.

That the malady was more or less typical of the variety Gravenstein in Australia, and possibly hereditary, was indicated by Lang (6) who states, "A peculiarity of this tree is the bossed and uneven appearance of the trunk and main branches, many of the branches having a twisted and gnarled appearance."

In discussing what he termed the constitutional diseases of fruit trees in Australia Campbell (2) included such "visible defects . . . . in the tissue as in fasciation . . . . when a shoot assumes a grotesque flattened appearance." McAlpine (7) also encountered the Gravenstein apple with its "ribbed trunk and twisted and deformed branches." From his observations in Australia he concluded that "as long as this variety was grafted on to Northern Spy stock it developed the deformity . . . . but whenever it was grafted on the Spy roots there was no appearance of it." McAlpine supported his statements with excellent photographs and suggested stock-scion incompatibility as the probable cause of the stem distortion.

An apple canker from an unnamed variety in Connecticut was described and illustrated by Clinton (3), who suggested that the trouble was probably due to winter injury. The description given by Clinton would be applicable to many of the cankers found on young Gravenstein branches affected with flat limb in Nova Scotia.

Thomas (8) treats flat limb as a virus disease and illustrates a rough bark condition produced "by inoculation" on *Pryocantha* as evidence

A few Gravenstein trees have been observed by the Dominion Botanist with flat limb symptoms in British Columbia. Mr. W. R. Foster, plant pathologist, British Columbia Department of Agriculture, Victoria, B.C. in correspondence has stated:—

"In the spring of 1935 six healthy scions of the Gravenstein variety were grafted on the flat limb tree at Nanaimo. The growth from these scions showed a pitted condition in the second year and a very marked malformation in the third year.

"Scions from the flat limb trees at Nanaimo and from Vancouver were placed on a healthy Gravenstein on the Experimental Station, Saanichton in 1938. The grafted Gravenstein tree showed noticeable symptoms of flat limb in 1942."

The Disease

The symptoms of the disease under consideration can be best described as a flattening of the wood of the branches. On 2- and 3-year-old wood a slight linear depression is apparent extending from one to several inches along the branch and for approximately half the branch diameter in width. The flattening becomes more pronounced as the branches get older since growth takes place only on the sides of the deformed areas (Figure 8).

FIGURE 8. Flat limb on young branches of Gravenstein.

On large branches and limbs the condition is very conspicuous (Figure 9). The flat areas twist with the strands of developing wood and give rise to the "twisted and deformed" description aptly made by McAlpine. The flattened areas frequently become infected with canker-causing fungi and the branches subsequently break with the load of fruit.

Concentric growth advances, as are found in European apple tree canker, cannot be observed in the flat limb condition.

One of the characteristic symptoms is the continuity of the bark over the affected area for several years. A cross section through an affected part shows lack of wood development in the flat areas and increased wood development on the margins (Figure 11). Black heart frequently accompanies the flat limb condition.

Observations

On one farm where the trouble has been observed for at least 40 years the owner has not seen it on any variety other than Gravenstein or its red sports. Scion wood has been taken from apparently normal Gravenstein trees, grafted on Stark stock and has developed typical flat limb within 5 years. Branches from the original stock did not produce similar symptoms. Golden Russet scions placed on an affected Gravenstein tree have failed to show symptoms of flat limb.

FIGURE 9. Flat limb on large branches of Gravenstein.

FIGURE 10. Flat limb on Wagener variety on Dudley stock.

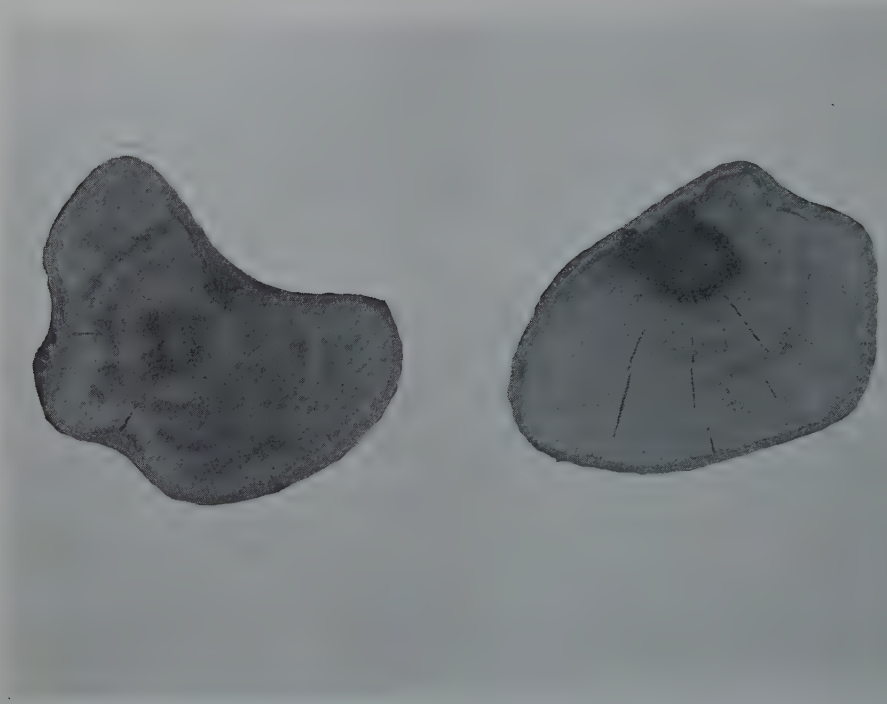

FIGURE 11. Cross section showing the eccentric wood development on flat limb.

On another farm several Dudley trees were grafted to Gravenstein. The owner had severely pruned many of these trees and pulled out others, on account of the flat limb produced on the scions. The same condition applies to a small block of Crimson Beauty trees. These when grafted to Gravenstein gave a large number of affected trees, but no visible symptoms of the condition were found on the Crimson Beauty or Dudley wood remaining on the trees.

In contrast to the early production of disease symptoms on grafted trees is the apparent lack of flat limb on budded nursery stock.

A condition very similar to flat limb was observed during the summer of 1938 on 3-year-old scions of the variety Wagener grafted on Dudley stocks (Figure 10); 9 trees out of 20 showed typical flattening of the branches. The trees from which the scion wood was taken appeared to be free from symptoms of flat limb. A few adjacent trees of the variety Gravenstein which had been grafted on Dudley stock some years previous to the Wageners also showed symptoms of flat limb in spite of severe pruning.

Experiments

During the spring of 1938 grafting experiments were conducted to compare the effect of rootstocks and method of grafting on the production of flat limb. Limited supplies of East Malling Type IX and Type XII stocks were available. The stocks were pruned to give a supply of piece

roots suitable for grafting. Scions were obtained from two sources. Healthy Gravenstein scions were obtained from a tree which had never shown flat limb, and flat limb scions were obtained from a tree which had shown the condition for a number of years.

All grafts were taped and waxed and suitably stored to permit callousing before planting. Some of the plants were subsequently lost from mice girdling and winter heaving during the winter of 1938-39 but a good proportion survived and have made fair growth. Notes have been made on plants showing flat limb symptoms (Table 1).

TABLE 1—FLAT LIMB ON GRAVENSTEIN

Scion and stock	Plants	Flat limb
Gravenstein on IX roots	35	0
Gravenstein on XII stocks	33	0
Flat limb on IX roots	30	10 (2 doubtful)
Flat limb on IX stocks	37	15
Flat limb on XII roots	15	1
Flat limb on XII stocks	5	2

Scions from the tree affected with flat limb have continued to reproduce the condition in less than 40% of the trials. It is interesting to note that the disease has not appeared in the piece root grafted plants as quickly as in the stock grafts, and furthermore that the Type XII roots are not as favourable to the development of flat limb as the Type IX.

DISCUSSION

The transmission of the disease by the use of scions from affected trees resembles the transmission of a virus, as suggested by Thomas. Evidence that flat limb may be transmitted by budding is incomplete. Bud grafts from sticks taken from the identical tree from which flat limb scions were obtained have failed to reproduce the flat limb condition in 5 years' growth, whereas grafts from the scion wood have shown the disease for 3 years. Such results are not readily explained.

If flat limb is due to a virus, it must be a very selective virus which causes the production of symptoms only under particular conditions. It appears typically on top worked trees and its history indicates that the stock on which it is grafted may have a controlling influence. The available evidence supports McAlpine's theory of stock scion incompatibility more than the virus theory as the initial cause of flat limb.

SUMMARY

Mosaic and false sting of apples are described as two virus diseases transmitted by grafting.

Negative results were obtained in attempts to transmit apple mosaic by expressed sap or by aphids.

There is a destruction of the green colouring matter of chloroplasts and a disorganization of the starch content of chlorotic areas in leaves affected with mosaic.

Fruit affected by the virus of false sting has an abnormal vascular pattern.

Both mosaic and false sting may be kept in check by rogueing and by exercising care in the selection of scions.

Flat limb is described as a branch distortion disease particularly affecting the variety Gravenstein but occasionally found on other varieties.

Successful transmission in grafts has been obtained in less than 50% of the trials but efforts have failed to transmit flat limb by budding.

Scions from normal Gravenstein trees top worked on the varieties Dudley and Crimson Beauty have frequently produced flat limb in the subsequent growth from the scions.

Root grafts have produced less flat limb than stock grafts and free growing E.M. type XII roots were not as favourable to the development of flat limb as E.M. type IX.

Available evidence supports McAlpine's theory of stock-scion relationship as the initial cause of flat limb of apples.

ACKNOWLEDGMENTS

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METHODS AND RATIONS FOR FATTENING POULTRY[1]

VIII. THE VALUE OF A PROTEIN SUPPLEMENT, OF ADDED RIBOFLAVIN, AND OF WATER TO DRINK BETWEEN FEEDINGS

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Research covering matters pertaining to feeding and management of fattening birds, previously reported (4) was continued. In an earlier test (1) the addition of meat meal to a fattening mash gave a marked increase in gains. In order to further substantiate this finding and to determine whether as great an increase could be obtained with a more efficient basal ration than that previously used, this work was repeated. The value of skim milk when used as a mixer for the fattening mash was shown to be much greater than that of water for production of gain and increase in percentage fat (3). The actual differences in favour of skim milk were so great as to suggest that the small amount of additional dry matter in the skim milk which the birds consumed could not be sufficient explanation for the increases observed. In view of the work of Sure *et al.* (6) indicating the role of vitamin B^2 (riboflavin) in increasing gain in weight through augmented deposition of fat, it was felt that the high content of riboflavin characteristic of skim milk might be responsible for the greater efficiency of this fluid in producing increased gain and fat in fattening birds. As a consequence, in these tests, crystalline riboflavin was added to the mixing water of the feed for a portion of the experimental birds in such quantity as to equal the usual concentration of that vitamin in skim milk. Still another problem was investigated, namely, the advisability of permitting the birds to have access to drinking water between feedings. It has been argued that the thirst occasioned by lack of drinking water between feedings made the birds more eager for their soft-mixed fattening feed thus causing them to eat more feed in an effort to slake their thirst and thereby bring about greater gains in weight.

MATERIALS AND METHODS

In this experiment 80 Barred Rock males of roaster age were fattened in individual cage laying batteries on 2 feedings daily for a period of 2 weeks. All birds were randomized according to hatch, battery, tier in the battery, feed and treatment. The following feeds were supplied to the birds:

Group A. Ground yellow corn.

Group B. Ground yellow corn + 10% meat meal (60% protein).

One-half of each of these groups received their ground mash soft-mixed with water, the other half having a quantity of pure crystalline riboflavin at a level equivalent to that found in skim milk added to the water used in mixing the wet mash. This was calculated on the basis of 2.2 micrograms of riboflavin per gram of liquid skim milk. The riboflavin was

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refrigerated and kept away from light until the moment of mixing with the water when it was immediately made into a wet mash and the feed given at once to the birds. It is felt that any loss of vitamin value would be negligible under these conditions.

These groups were again subdivided in treatment; one-half had water to drink between feedings (7.00 a.m. and 5 p.m.) until within 1 hour of feeding time; the other half had no drink available, and were forced to rely on the moisture from the wet mixed feed, the proportion of fluid to mash being $1 \div 1$ (51% moisture).

The data were analyzed by the methods of variance and covariance for gain and increase in percentage fat, and observed and corrected adjusted means were calculated by previously reported methods (2, 3).

RESULTS

Table 1 shows the observed and adjusted mean values for gain in body weight and increase in percentage fat.

TABLE 1.—GAIN IN BODY WEIGHT AND INCREASE IN PERCENTAGE FAT

Treatment	Gain in body weight		Increase in percentage fat	
	Observed*	Adjusted	Observed*	Adjusted
	grams	grams	%	%
Ground yellow corn	148.63	154.75	22.17	22.26
Ground yellow corn + 10 % meat meal	254.40	248.28	20.76	20.67
Feed mixed with water	209.03	210.69	21.85	21.79
Feed mixed with water containing riboflavin	194.00	192.36	21.07	21.13
Water to drink between feedings	253.75	240.38	19.98	19.89
No water to drink between feedings	149.28	162.64	22.95	23.05

* Necessary difference for odds of 19 : 1 (observed means, only): for gain (40 birds per group), 45.60; for increase in percentage fat, 4.49.

A consideration of the data in Table 1 shows some highly significant differences in gain on different feeds or treatments The addition of meat meal to the ground corn mash caused a 41% increase in gain over the mash alone. A similar difference was brought about when water for drinking was available to the birds between feedings. The increase in percentage fat did not differ significantly for the different treatments.

If the adjusted means are considered, that is to say, values calculated on the basis of all birds starting at the same initial body weight, with the same initial percentage fat and making the same increase in percentage fat, the gains are again highly significant and in favour of meat meal and water to drink between feedings. The means for increase in percentage fat with initial weight, gain and initial percentage fat held constant, show significance only in one comparison, namely a greater percentage of increase in fat with no water to drink between feedings. It is worthy of note that the only difference for increase in percentage fat of any size in the observed means also occurs in this same comparison.

DISCUSSION

It has been possible, through this experiment, to confirm previous findings indicating that the addition of meat meal at a level of 10% causes greatly increased gain in weight. Not only was this supplement able to bring about an increase when added to a mediocre basal mash but also when added to ground corn which in itself is one of the most satisfactory grains for fattening. The increased gain in this instance was sufficient to pay for the additional cost of the meat meal several times over. A surprising result of the experiment was the marked increase in gain brought about by making drinking water available between feedings. It should be pointed out in this connection that the percentage of moisture in the feed given, that is, whether the fattening feed is mixed to a fluid consistency, which is the usual practice, or to a firmer consistency, as was the case in this test (equal parts of ground grain and water) will determine the degree of additional gain which may be expected when drinking water is available between feedings. It is a known fact that lack of sufficient water causes serious disturbances in the organism including dehydration of tissues to maintain the normal water content of the blood. In addition, the laying down of muscular tissue which is high in moisture would necessarily require an adequate supply of ingested fluid. The laying down of fat, however, does not require a large moisture supply since fat itself contains only approximately 20% moisture. The evidence would indicate actually that the is laid down at the expense of moisture and is therefore sparing of it since an almost perfect negative correlation between the content of fat and moisture of poultry was obtained by Holcomb and Maw (5). For the tendency towards lower increase in percentage fat when water is given between feedings no explanation seems to be immediately available. While there is no doubt that such a tendency does exist in these data, the practical importance of this small difference would be limited since all groups concerned made a sufficiently large increase in fat to place a very large proportion of the dressed carcasses in A grade. It would seem that even if fattening feed is given in very moist form as a precautionary measure water should be given to drink between feeds.

Since the addition of pure riboflavin in quantities equal to those found in skim milk gave no increase over water alone, it seems evident that the riboflavin content of skim milk cannot alone explain its superiority to water (3).

SUMMARY

1. The addition of 10% of meat meal to a flattening mash of ground corn gave a very large increase in gain in weight over that of the same mash not thus supplemented.

2. When the birds were permitted access to drinking water between feedings their gain in weight was very greatly increased.

3. The riboflavin content of skim milk apparently does not explain the previously established much greater efficiency of skim milk than water in fattening.

ACKNOWLEDGMENT

It is a pleasure to acknowledge the co-operation of the Division of Chemistry, Science Services, in making the fat determinations required for this study.

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THE INFLUENCE OF SOME HORTICULTURAL PRACTICES ON BITTER PIT IN OKANAGAN-GROWN APPLES[1]

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Bitter pit of apples may be described as a disorder resulting from functional disturbances within the fruit during growth and storage. It is characterized by brownish sunken pits or spots which may be few or numerous. Visible spotting, if present before harvest, usually appears near the calyx end of the apple and may be limited to one section or may almost encircle the fruit. Following harvest, visible spotting may develop on various areas of the fruit's surface. The flesh may be affected in a shallow area just below the skin, or the pitting may extend throughout the fruit to the core line. Generally, after 2 to 3 weeks' storage at 70° F., the maximum pitting will have developed, and any apples not affected then will remain free from the disorder.

Bitter pit has been found in all important apple growing sections of the world. Fortunately, many varieties are quite resistant to bitter pit. However, a variety showing resistance in one district may be susceptible when grown in another area.

In British Columbia severe losses have been suffered from bitter pit over a period of several years. Such losses prompted the following resolution which was adopted by the Canadian Horticultural Council in 1931: "Whereas a very serious loss is annually sustained by the growers of certain varieties of apples through bitter pit, be it resolved that the Department of Agriculture be requested to conduct research and experimental work with a view to ascertaining the cause of and a remedy for bitter pit in apples."

In 1937 exceptionally heavy losses were sustained in the southern area of the Okanagan Valley. At this time the Laboratory of Plant Pathology and the Experimental Station at Summerland were both consulted regarding control measures. Shippers were anxious to know if any methods of handling and storing the crop could be adopted to reduce such heavy wastage. Before an intelligent answer could be given a number of factors required investigation. Both orchard and storage conditions as well as methods of handling needed careful study. To ascertain whether or not the losses were sufficiently serious to justify the expense of a thorough investigation, a questionnaire was sent by the Experimental Station to all registered tree fruit shippers in British Columbia, several fruit inspectors of the Dominion Marketing Service, and a number of fruit growers.

Information was solicited regarding varieties affected by bitter pit, approximate loss in each variety, the identity of orchards most seriously affected, and a personal opinion as to whether or not the bitter pit problem justified comprehensive investigation.

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[4] Superintendent.

Replies were received from 14 districts, in all but 2 of which bitter pit was considered to be of commercial importance. The most serious losses were reported from orchards in the southern Okanagan Valley.

While bitter pit was reported in a long list of varieties including Delicious, Winesap, Grimes Golden, Jonathan, Winter Banana, Spitzenburg, Rome Beauty, and Wagener, the most serious losses were in Cox Orange, Northern Spy, and Newtown. Of these varieties, Newtown is extensively planted, but Cox Orange and Northern Spy are grown to only a limited extent in the Okanagan Valley.

Losses as high as 55% of the crop were reported in Cox Orange and Northern Spy from some orchards, and the disorder was prevalent in these varieties from many different orchards. With Newtown the losses in individual orchards were less serious, but the heavy plantings of this variety made the total loss comparatively great.

REVIEW OF LITERATURE

The wide occurrence of bitter pit in apples has made this disease the subject of much investigation. Certain varieties are more susceptible than others, but pitting has been reported in many varieties. Different localities, soils, cultural treatments, harvesting and storage procedures have all been shown to have their effect upon the incidence of this disease. The existing literature on bitter pit has been assembled chronologically under different headings and briefly summarized by Barker (3). This comprehensive bibliography published in 1934 can scarcely be improved upon, so only a few especially pertinent references to the literature will be made in this report.

There was some confusion in the earlier literature between true bitter pit and orchard pitting (cork). However, even before it was discovered that the "cork" diseases (drought spot, etc.) were the result of a boron deficiency McLarty (14), Atkinson (2), and Carne *et al.* (5) had distinguished the cork diseases which they called "tree pit" from what they called "true" bitter pit developing in storage. In fact they stated (5) that: "The disease is actually initiated in the apples by picking them while in a rapidly ripening but immature condition." However, Eaves and Hill (11) recognize two forms of true bitter pit, one which becomes evident on the tree, and a delayed manifestation of the same disorder occurring in storage. Experience at the Summerland Experimental Station indicates likewise that bitter pit may make its appearance either before or after picking.

Orchard conditions such as amount and frequency of irrigation, vigour of trees, fertilizer applications, size of crop, etc., have all been shown to affect markedly the incidence and severity of bitter pit. These all affect the nutritional level of the tree with respect to the availability of nitrogen and carbohydrate compounds which has led Davis (10) to place bitter pit in the nitrogen-carbohydrate group of disorders. Heavily pruned, over-vegetative trees, trees starved or over-abundantly supplied with water, trees bearing light crops either because of the biennial bearing habit or excessive dropping of fruit, or trees in any abnormal state of carbohydrate-nitrogen metabolism have been shown to be far more

susceptible to bitter pit than trees in normal vigour and bearing normal crops. For a detailed survey of this aspect of the problem, Barker's (3) bibliography should be consulted.

Numerous investigators, Carne *et al.* (5, 6), Butler (4), Allen (1), Thomas and Raphael (20), and others, have studied the relationship between maturity of apples at harvest and the subsequent development of bitter pit in a number of varieties. These investigators obtained a marked reduction in bitter pit development in pit-susceptible apples by harvesting them in a mature rather than immature condition. The recommendation in most cases is to harvest the crop just as mature as possible without rendering the fruit liable to other physiological storage diseases. In connection with bitter pit investigations the iodine-starch reaction has been extensively studied as a means of judging correct harvesting maturity. .Carne *et al.* (5), Tiller (21), and Carne (8) have based their practical harvesting recommendations for different varieties on the stage of starch hydrolysis.

With regard to the effect of storage treatments upon bitter pit development, the evidence is somewhat conflicting. Eaves and Hill (11), Overholser (15), and others, have presented evidence indicating that low temperatures retard and high temperatures hasten the manifestation of pit lesions. On the other hand, Allen (1) found that fruit harvested and held continuously at a temperature of 70° F. or higher developed less bitter pit at and during the time it was in the best condition for eating, than fruit ripened at 50° F., or previously held at 32° F. for short periods. Cummings and Dunning (9) found that bitter pit developed most rapidly during the first 2 or 3 months of storage and usually ceased to develop after midwinter.

McAlpine (13), Smith (17), Overholser (15), and others have shown that the tendency to bitter pit is greatest in large apples and least in small apples. In this connection it should be borne in mind that the size of the crop has a direct influence on size of fruit, heavy crop fruit tending to be small and light crop fruit large. McAlpine (12), Smith (17), Butler (4), Carne (5), etc., have also mentioned the relationship between light cropping and high incidence of bitter pit. Cummings and Dunning (9) failed to find an association between size of crop and amount of pitted fruit.

Practical application of the relationship between fruit size and liability to bitter pit has been undertaken by Carne and Martin (7), and Carne (8). These investigators have set forth recommendations as to the maximum size of different varieties permissible for export to the overseas market so as to reduce wastage.

Several theories as to the cause of bitter pit have been advanced such as the "crushed cell theory", "the starved cell theory", "the concentrated cell-sap theory", and "arsenical poisoning theory". However, none of these theories has been proven. A recent theory has been put forward by Carne *et al.* (6) who suggest that "bitter pit is a necrosis of immature starch-filled tissues of rapidly growing apples resulting from excessive transpiration, followed by osmotic action between the starch-filled cells and those in which the starch has been largely or completely changed to sugar." To substantiate their theory they point out that ripening of apples is uneven and that the bitter pit tissues contain starch. On the other hand, Smock

and Van Doren (19) have observed that in the early stages of bitter pit development, starch can be observed in surrounding healthy cells as well as in the pitted areas of apple tissue.

It has long been suspected that bitter pit involves a water relationship in the tree and fruit, but it remained for Smock (18) to produce the first direct statistical evidence pointing to this fact. In experiments conducted over a 3-year period with Northern Spy, Rhode Island Greening, and York Imperial, Smock showed that bitter pit is associated with the relative abilities of leaves and fruits to compete for water. Leaves ordinarily have higher osmotic values than fruits, and treatments such as ringing, fertilizing with nitrogenous fertilizers, and heavy thinning which increased the differential in osmotic concentrations in favour of the leaves, correspondingly increased bitter pit. On the other hand, defoliation which improved the water competing power of the fruits markedly lowered bitter pit. Further evidence of the importance of the water relationship was indicated by the fact that by waxing apples and by storing them under high humidities, time of appearance of bitter pit was delayed.

INVESTIGATIONS CONDUCTED IN BRITISH COLUMBIA

With the foregoing evidence of the serious nature of bitter pit and the many factors influencing susceptibility of fruit to the disease, a project was planned to investigate the problem as it occurs in the Okanagan Valley of British Columbia. This project was undertaken in co-operation with the Summerland Laboratory of Plant Pathology and comprised two phases of study, namely: (1) the fundamental nature and causes of the disorder, to be investigated by the Laboratory; and (2) horticultural methods of handling apple crops susceptible to bitter pit, to be investigated by the Summerland Experimental Station. It is this second phase of the investigation, the object of which was to ascertain methods of preventing, reducing, or controlling the wastage caused by bitter pit, which is dealt with in this report.

Having regard to the serious losses experienced from bitter pit in Cox Orange, Northern Spy, and Newtown apples, experiments were designed to ascertain the influence of harvesting and storage treatments on the prevalence of the disease in fruit of these varieties. To secure information concerning the relation of orchard conditions to the bitter pit problem, detailed records were made of such factors as soil type, fertilizer treatment, irrigation practice, age, and amount of crop carried by all trees used in the harvesting and storage experiments. To check the influence of seasonal weather conditions, the experiments were conducted over a period of several years. The procedures followed and results secured are presented separately for each of the three varieties.

Experiments with Cox Orange

Experiments with the Cox Orange variety were conducted over a 2-year period. In 1938 and again in 1939 fruit was secured from the orchards of Messrs. L. V. Francis and J. Riddle in the Penticton-Naramata area.

In the Francis orchard the trees are planted 25 feet apart on the square, and were about 25 years old. They were vigorous and had produced yields as high as 50 bushel boxes per tree in their "on" year. Most of them had developed the biennial bearing habit, producing a heavy crop one year and a light crop the next. However, they did not all bear heavy crops the same year. Comparatively light pruning had been practised and light thinning of fruit had been performed on trees carrying heavy crops. The soil is a deep, fertile silt and is almost level. Irrigation water was applied in 3 furrows between tree rows for 3 or 4 days every 14 days during the irrigation season. Fertilizer had been applied in the form of a 6-10-10 mixture, or as ammonium sulphate occasionally when the trees seemed to need it. Owing to the dense shade cast by the trees, there was only sparse cover crop growth and no cultivation had been given in recent years.

In the Riddle orchard the trees were about 25 years old. They varied in size and vigour, apparently as a result of variable soil conditions. The land slopes rather sharply to the west and the soil ranges from light sandy loam to silt loam of variable depth. The subsoil ranges from coarse gravel to clay. Seepage had caused trouble in some sections of the orchard. There was a fairly heavy cover crop of weeds, grasses and alfalfa which had been disced once a year. Irrigation water was applied by the furrow method. A 6-10-4 fertilizer was applied at the rate of 10 pounds per tree in 1937, and sulphate of ammonia was applied at the rate of 6 pounds per tree in 1938. Pruning had consisted of a light annual thinning out of branches. Most of the trees had developed the biennial bearing habit, and light thinning of the fruit had been practised on the heavy crop trees only.

In obtaining fruit for harvesting and storage tests care was taken to pick separately from both heavy and light crop trees. In all cases the light crop trees selected had less than a third of a full crop yet carried sufficient fruit to provide the required experimental material.

For the date of picking experiments, 5 light crop and 5 heavy crop trees were selected in each of the Francis and Riddle orchards. With the exception of 3, the same trees were used in 1939 as in 1938. From each tree at least 25 representative apples were picked each week over a period of 8 weeks beginning before, and extending well after the customary harvesting season. Five apples from each picking from each tree were used for maturity tests including hardness, skin colour, flesh colour, iodine test, and water core. At least 20 apples from each picking from each tree were packed in peach flats, placed in storage, and examined at frequent intervals to determine development of bitter pit, shrivelling, flavour, quality, mealiness, and breakdown.

The fruit used in comparative storage tests was secured from several light crop and several heavy crop trees of each variety. Two bushel-boxes of apples from heavy crop and 2 from light crop trees were stored unwrapped at 60° F. and a relative humidity of 85%. These boxes were used as checks to ascertain the influence of various temperature, humidity, and wrapping treatments on the development of bitter pit.

Amount of Crop and Bitter Pit in Cox Orange

The percentage of bitter pit which developed in fruit from individual trees in the Francis and Riddle orchards in 1938 and 1939 is shown in Table 1, together with information as to the amount of crop carried by each tree each year. These data represent an average of the bitter pit development in the first 5 pickings from each of 17 trees which were harvested in both 1938 and 1939.

TABLE 1.—AMOUNT OF CROP AND BITTER PIT IN COX ORANGE

Tree no.	Performance 1938		Performance 1939	
	Crop	Bitter pit	Crop	Bitter pit
		%		%
Francis Orchard				
4	Heavy	12	Light	88
6	Heavy	13	Light	20
7	Heavy	9	Light	85
8	Heavy	34	Light	36
10	Heavy	35	Light	26
1	Light	73	Heavy	5
2	Light	68	Heavy	4
3	Light	68	Heavy	2
5	Light	55	Heavy	6
Riddle Orchard				
1	Heavy	17	Light	64
4	Heavy	21	Light	78
8	Heavy	16	Light	76
10	Heavy	20	Light	85
2	Light	50	Heavy	69
3	Heavy	17	Heavy	19
5	Light	66	Heavy	35
9	Light	41	Heavy	4

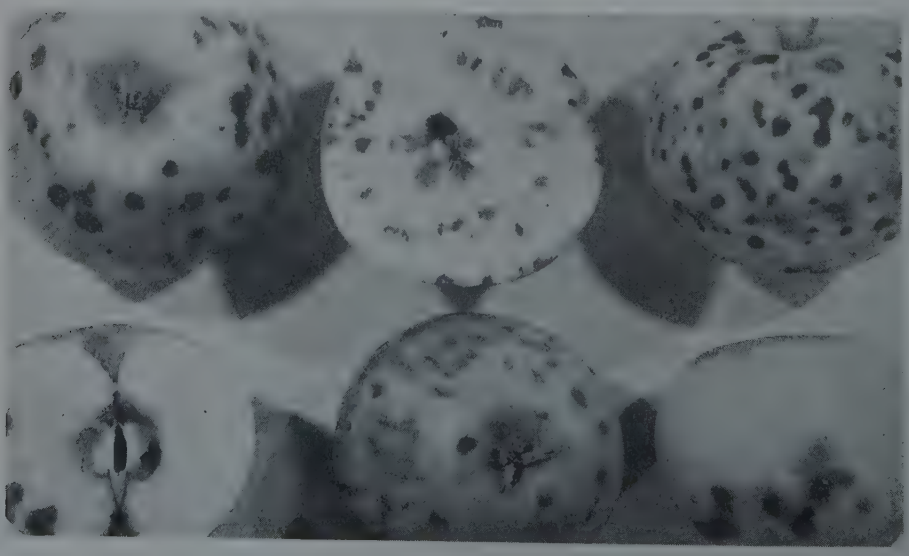

FIGURE 1. Bitter pit in Cox Orange.

From the data presented in Table 1 it is apparent that some bitter pit developed in the fruit from each tree each year, but that with almost every tree the percentage of fruit affected with bitter pit was materially greater in the light crop than in the heavy crop year. Additional data substantiating these findings are presented elsewhere in this report.

Date of Picking and Bitter Pit in Cox Orange

The influence of date of picking on development of bitter pit in Cox Orange is shown in Table 2. The figures represent the average percentage of bitter pit which developed in the fruit picked each week over a period of 6 weeks from groups of heavy and light crop trees in the Francis and Riddle orchards.

It will be noted that there was a strong tendency for the early picked fruit to develop more bitter pit than the later picked fruit. However, a fairly high percentage of bitter pit developed in the fruit from even the latest pickings, especially with the light crop trees.

TABLE 2.—DATE OF PICKING AND BITTER PIT IN COX ORANGE APPLES OBTAINED FROM FRANCIS AND RIDDLE ORCHARDS

Year	Orchard	Crop	Bitter pit in fruit from each picking					
			Aug. 15	Aug. 22	Aug. 29	Sept. 5	Sept. 12	Sept. 19
			%	%	%	%	%	%
1938	Francis	Heavy	21	33	25	19	11	6
1938	Francis	Light	52	62	59	59	50	30
1938	Riddle	Heavy	32	27	21	11	8	—
1938	Riddle	Light	66	50	40	29	33	31
1939	Francis	Heavy	14	8	0	0	1	6
1939	Francis	Light	74	55	53	43	31	32
1939	Riddle	Heavy	41	37	23	21	21	20
1939	Riddle	Light	84	81	75	54	74	46

Date of Picking and Breakdown in Cox Orange

Delayed harvesting of Cox Orange increased the tendency of the fruit to develop a form of breakdown similar to that often found in the Jonathan variety. Evidence supporting this statement is presented in Table 3. The data included in this table were secured from 8 weekly pickings made from trees in the Riddle orchard in 1938. Similar data were secured from the Francis orchard in 1938 and from both orchards in 1939.

It will be noted from the figures presented in Table 3 that in the fruit from the light crop trees there was some breakdown even in the early pickings, but that the percentage of breakdown was much greater in the late pickings.

Comparatively little breakdown developed in fruit picked from heavy crop trees up to September 12 on which date the entire crop from 4 out of the 5 trees was harvested. With the fifth tree from which 3 later weekly pickings were made there was a progressive increase in the percentage of fruit which developed breakdown.

TABLE 3.—DATE OF PICKING AND BREAKDOWN IN COX ORANGE APPLES OBTAINED FROM RIDDLE ORCHARD, 1938

Tree no.	Crop	Breakdown in fruit from each picking							
		Aug. 15	Aug. 22	Aug. 29	Sept. 6	Sept. 12	Sept. 19	Sept. 26	Oct. 4
		%	%	%	%	%	%	%	%
1	Heavy	0	0	9	0	2	5	9	17
3	Heavy	0	0	3	5	0	—	—	—
4	Heavy	0	0	2	0	5	—	—	—
8	Heavy	0	0	2	0	0	—	—	—
10	Heavy	0	2	0	0	0	—	—	—
2	Light	6	6	26	50	45	66	48	67
5	Light	6	3	7	0	3	4	13	38
6	Light	6	0	3	11	6	5	7	16
7	Light	0	3	5	6	9	15	22	36
9	Light	5	7	9	7	13	24	14	30

From these findings it is readily apparent that with the Cox Orange too late harvesting is likely to produce as disastrous results as too early harvesting. Accordingly, there is a real need for simple yet reliable maturity indices for determining the correct stage of maturity at which to harvest Cox Orange.

Maturity Indices for Cox Orange

Comparison of careful records made at harvest time with subsequent behaviour of the fruit in storage and ripening rooms revealed that there are several useful maturity indices for Cox Orange. In both 1938 and 1939 fruit from heavy crop trees in the Francis and Riddle orchards picked on September 6 and 12 was comparatively free from bitter pit and breakdown and of superior dessert quality, as indicated by flavour, texture, juiciness, and general attractiveness.

As date of optimum maturity for apples varies somewhat from year to year, it is important to note that when in satisfactory harvesting condition Cox Orange from heavy crop trees had the following characteristics: skin colour about Stage 2 on the Jonathan colour chart devised by Palmer (16), flesh colour white with green colour faded out of vascular bundles, and seed colour brown. The starch-iodine reaction as described by Carne *et al.* (5) revealed that in specimens picked from the same tree on the same date there was a good deal of variation in the amount of starch present in the core and flesh, especially in fruit from light crop trees. Nevertheless, there was a progressive disappearance of starch with each successive picking. The photographs presented in Figure 2 give an indication of the range of starch-iodine reaction found in Cox Orange picked from heavy crop trees on August 23 and on September 6 and 26, 1939. It will be noted that at desirable picking maturity starch had disappeared from the core area and had also begun to disappear from the flesh, producing a slightly mottled effect.

The maturity of fruit on light crop trees proved difficult to determine as the various maturity tests gave somewhat inconsistent results. Skin colour and flesh colour changes indicated that fruits on light crop trees

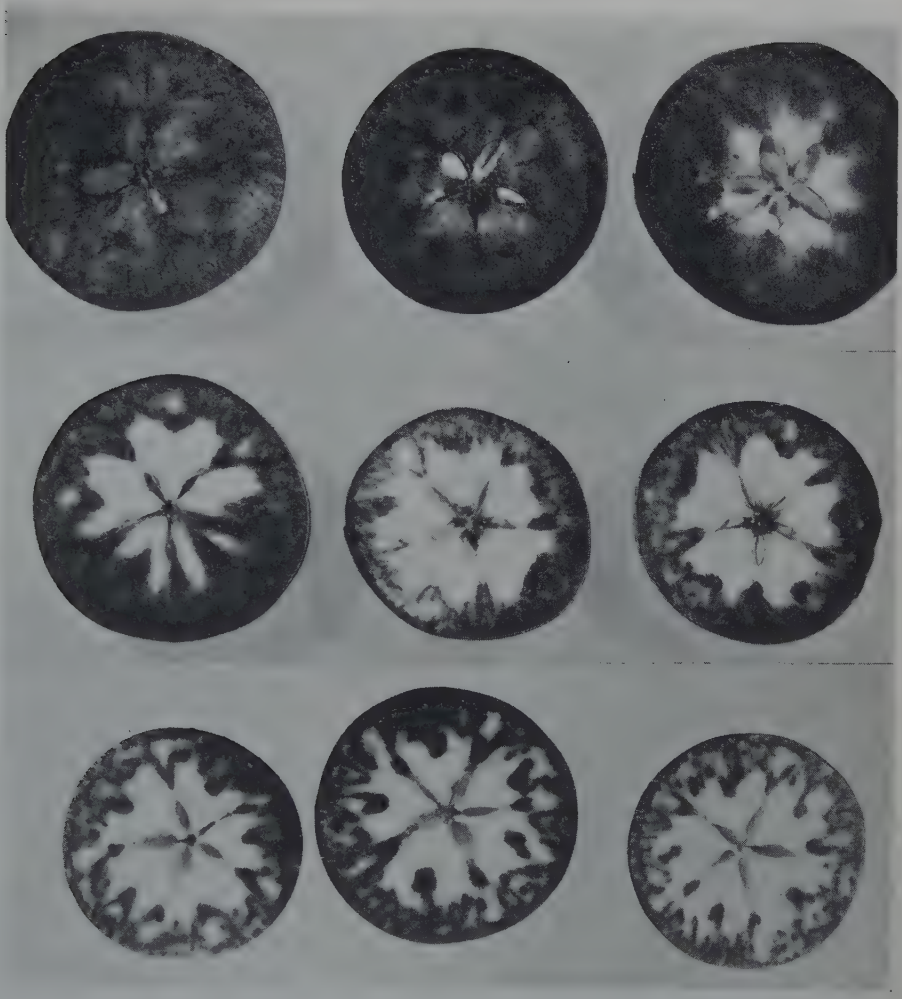

FIGURE 2. Starch-iodine reaction in Cox Orange picked from heavy crop trees in 1939. Top row picked August 23, centre row September 6, bottom row September 26. Specimens in centre row illustrate reaction at desirable maturity.

matured earlier than those on heavy crop trees, whereas seed colour and the iodine test suggested that the light crop trees matured their crop later than heavy crop trees. Furthermore, there was evidence of great variability in maturity of the apples on light crop trees.

These findings indicate that in determining the correct time to pick Cox Orange it is important to make maturity tests with normal fruits from trees carrying a full crop.

Storage Conditions and Bitter Pit in Cox Orange

The data presented in Table 4 exemplify the influence of storage treatment on the development of bitter pit in Cox Orange. These data were secured from fruit picked on September 6, placed in storage immediately,

and examined for bitter pit on October 6 and December 6. Two bushel boxes of apples from each of 2 light and 2 heavy crop trees were subjected to each storage treatment.

The figures in Table 4 show the percentage of bitter pit which had developed after 1 and 3 months' storage under the temperature and humidity conditions indicated.

TABLE 4.—STORAGE TREATMENT AND BITTER PIT IN COX ORANGE APPLES OBTAINED FROM FRANCIS AND RIDDLE ORCHARDS SEPTEMBER 6, 1938

Storage treatment (Fruit held loose at relative humidity 85, unless otherwise stated)	Bitter pit after storage for 1 and 3 months			
	Heavy crop trees		Light crop trees	
	Oct. 6	Dec. 6	Oct. 6	Dec. 6
Temp.	%	%	%	%
60° F. within 24 hours	5	10	30	66
40° F. within 24 hours	0	6	32	63
32° F. within 24 hours	0	1	0	34
32° F. after 1 week at 60° F.	0	0	25	25
32° F. after 2 weeks at 60° F.	7	7	32	36
40° F., humidity 60	1	9	40	71
40° F., humidity 100	0	7	47	60
40° F., oiled wraps	2	8	22	46

It is evident that prompt storage at 32° F. delayed and to some extent reduced the development of bitter pit, whereas prompt storage at 40° F. merely delayed without reducing the amount of pit which finally developed. Humidity of the storage atmosphere and wrapping in oiled paper had no significant influence on development of bitter pit.

EXPERIMENTS WITH NORTHERN SPY

Experiments with Northern Spy were conducted over a 2-year period following much the same procedure as with Cox Orange. Fruit was secured in 1938 and again in 1939 from the orchard of Mr. H. R. J. Richards in Summerland.

In this orchard the trees were about 35 years of age, planted 30 feet apart and had received good orchard culture. The soil is mostly a deep loamy silt, with small amounts of gravel at one point. A cover crop of alfalfa had been maintained for some years although at the time of this experiment growth was rather sparse, probably due to shading. A complete commercial fertilizer had been applied annually for 4 years and boron was applied in 1937. The trees all appeared vigorous but there was no evidence of excess nitrogen. Soil moisture was well maintained by about 7 irrigations during the season.

Production in this orchard had been generally heavy, but many of the trees had developed the biennial bearing habit. For example, tree No. 5 in this experiment produced 78 bushel boxes of apples in 1937 but only 12 boxes in 1938.

Pruning had been light following a thinning out of strong laterals and airly heavy cutting back in 1935–36. In 1938, moderate thinning of the

crop was practised on the heavy crop trees. In 1939 the crop was not thinned, resulting in many small sizes and poorly coloured fruit. The owner reported that bitter pit had occurred annually in fruit from all parts of the orchard.

To secure fruit for date of picking experiments 5 heavy crop and 5 light crop trees were selected in 1938. With one or two exceptions, the same trees were used again the following year. Most of the trees which carried a heavy crop in 1938 carried a light crop in 1939 and vice versa. Representative pickings of at least 25 apples were made from each tree each week from September 21 to October 19. The apples were picked at random from around the tree and from the top centre. Fruit was placed in storage at 32° F. on the day picked and removed for examination after the same lapse of time for each lot. The 1938 fruit remained in cold storage for 4 months, the 1939 fruit for 5 weeks. The percentage of bitter pit which had developed in fruit from each picking from each tree after 2 weeks in a ripening room was recorded. Data were also collected regarding the influence of date of picking on development of quality and breakdown.

Amount of Crop and Bitter Pit in Northern Spy

The percentage of bitter pit which developed in fruit from individual trees carrying light and heavy crops is shown for each of the years 1938 and 1939 in Table 5.

TABLE 5.—AMOUNT OF CROP AND BITTER PIT IN NORTHERN SPY APPLES OBTAINED FROM RICHARDS ORCHARD

Tree no.	Performance 1938		Performance 1939	
	Crop	Bitter pit	Crop	Bitter pit
		%		%
1	Light	33	Heavy	15
3	Light	31	Light	20
5	Light	41	Very heavy	1
6	Light	32	Very heavy	0
8	Light	35	Light	38
2	Heavy	8	Heavy	2
4	Heavy	8	Light	5
7	Heavy	10	Light	33
9	Heavy	6	Very heavy	0
10	Heavy	12	Light	2

These data were secured from fruit included in 5 weekly pickings made from each tree. It will be noted that in most cases there was a great deal of bitter pit in fruit from trees carrying a light crop, materially less in fruit from trees carrying a heavy crop, and practically none in fruit from trees carrying a very heavy crop. In this connection it may be well to mention that the fruit from trees carrying a very heavy crop tended to run small in size and poor in colour.

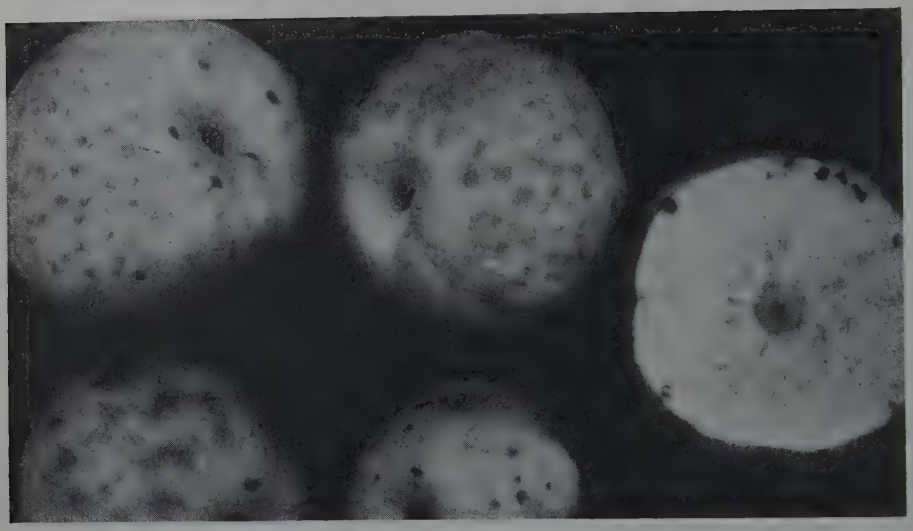

FIGURE 3. Bitter pit in Northern Spy.

Date of Picking and Bitter Pit in Northern Spy

The effect of date of picking on development of bitter pit in Northern Spy is shown in Table 6. The figures represent the average percentage of bitter pit which developed in fruit picked at weekly intervals from groups of light and heavy crop trees.

It will be noted that there was a tendency for less bitter pit to develop in the late picked than in the early picked fruit but that a material amount of bitter pit developed in the fruit of even the final picking, especially with light crop trees.

TABLE 6.—DATE OF PICKING AND BITTER PIT IN NORTHERN SPY APPLES OBTAINED FROM RICHARDS ORCHARD

Year	Crop	Bitter pit in fruit from each picking				
		Sept. 21	Sept. 28	Oct. 5	Oct. 13	Oct. 19
		%	%	%	%	%
1938	Heavy	9	10	7	8	No fruit
1938	Light	34	45	25	26	No fruit
1939	Heavy	4	3	7	3	1
1939	Light	22	26	25	12	12

Date of Picking and Breakdown in Northern Spy

The fruit from each picking was examined for development of flesh breakdown. The apples picked in 1938 were held at 32° F. until the end of February, removed to a 60° F. ripening room for 2 weeks, then cut to determine development of breakdown. The results are presented in Table 7.

It will be noted that a few fruits from each tree developed breakdown, but there was a tendency for more breakdown to develop in the fruit from light crop trees, especially in the final picking.

TABLE 7.—DATE OF PICKING AND BREAKDOWN IN NORTHERN SPY APPLES OBTAINED FROM RICHARDS ORCHARD 1938

Tree no.	Crop	Breakdown in fruit from each picking			
		Sept. 21	Sept. 28	Oct. 5	Oct. 13
		%	%	%	%
1	Light	2	2	3	4
3	Light	4	4	2	9
5	Light	5	4	2	4
6	Light	1	2	4	4
8	Light	2	2	1	7
2	Heavy	1	0	1	0
4	Heavy	0	2	0	0
7	Heavy	1	0	3	0
9	Heavy	0	0	0	1
10	Heavy	2	2	2	0

In 1939 the apples were held in cold storage till the end of November, removed to the ripening room for 2 weeks, and then examined. At that time there was extensive development of bitter pit but no evidence of breakdown.

Maturity Indices for Northern Spy

A number of apples from each picking, from each tree, were used to record hardness, skin colour, flesh colour, seed colour, and starch-iodine reaction. The average hardness of the apples was recorded at each picking with a Ballauf pressure tester, but differences were too small to be of value as a maturity test. Changes in skin colour were recorded for fruit on each of the 10 trees at each picking. The colours varied somewhat but there was a gradual change from green towards yellow from the first to last pickings. The ground colour of the light crop apples was generally slightly more advanced than that of heavy crop apples at all pickings. This was also true of the change in flesh colour which became creamy white in light crop apples while still greenish white in the heavy crop apples. Seeds were brown at all dates of picking. The iodine test revealed that starch was present in the core area as well as in the flesh in early picked fruit. In later pickings the starch disappeared from the core, and starch-free areas appeared in the flesh. The range of starch-iodine reaction in Northern Spy picked from heavy crop trees on September 21 and on October 6 and 13, 1940, is shown in Figure 4.

The stage of maturity at which the fruit was picked had a decided influence on quality. Apples harvested on October 5 and later dates were much superior in quality to apples harvested earlier.

In both 1938 and 1939 most of the Northern Spy picked from heavy crop trees on October 5 had the following maturity characteristics: skin colour 2 on the Jonathan colour chart, flesh colour creamy white with greenish core lines, seeds brown, and core area free from starch.

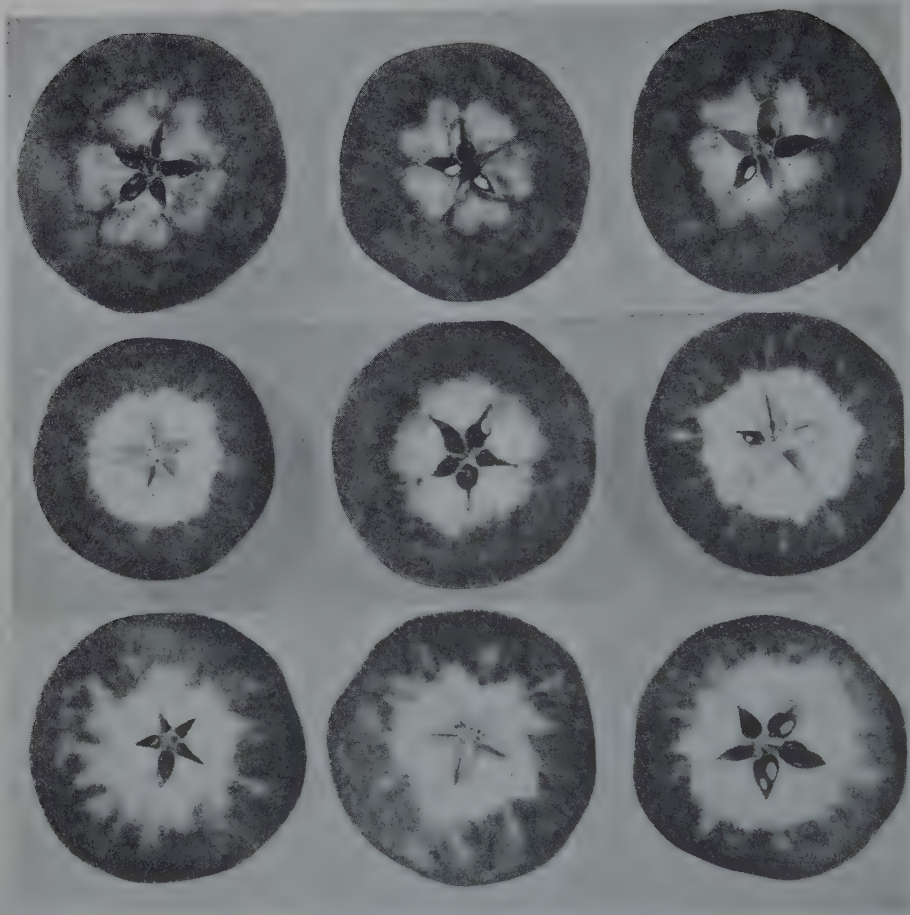

FIGURE 4. Starch-iodine reaction in Northern Spy picked from heavy crop trees in 1940. Top row picked September 21, centre row October 6, bottom row October 13. Specimens in centre row illustrate reaction at desirable maturity.

Storage Conditions and Bitter Pit in Northern Spy

Storage trials were conducted with Northern Spy in 1938 following the same technique used with Cox Orange. Sufficient apples were picked on October 13 from 2 heavy and 2 light crop trees to provide a bushel box from each tree for each of the storage treatments indicated in Table 8. Final examinations for bitter pit were made the following March. A similar experiment comparing 32° F. and 40° F. storage only was conducted in 1939. The results of both experiments are presented in Table 8.

While the data presented in Table 8 are not entirely consistent they suggest that prompt storage at 32° F. has a slight tendency to prevent the development of bitter pit in Northern Spy.

EXPERIMENTS WITH NEWTOWN

Experiments have been conducted with the Newtown variety over a period of 5 years, 1938 to 1942 inclusive. The experiments involved apples

TABLE 8.—STORAGE TREATMENT AND BITTER PIT IN NORTHERN SPY APPLES OBTAINED FROM RICHARDS ORCHARD, OCTOBER 13, 1938, AND OCTOBER 20, 1939

Storage treatment (Fruit held loose at relative humidity 85, unless otherwise stated)	Bitter pit after five months' storage			
	Results in 1938		Results in 1939	
	Heavy	Light	Heavy	Light
Temp.	%	%	%	%
60° F. within 24 hours	8	35	—	—
40° F. within 24 hours	20	36	3	8
32° F. within 24 hours	7	22	0	3
32° F. after 1 week at 60° F.	8	20	—	—
32° F. after 2 weeks at 60° F.	7	10	—	—
40° F., relative humidity 60	6	28	—	—
40° F., relative humidity 100	5	31	—	—
40° F., oiled wraps	17	44	—	—
32° F., oiled wraps	4	7	—	—
60° F., oiled wraps	5	28	—	—

from orchards owned by Mr. B. Underwood of Summerland; Messrs. T. E. Davenport, S. Lucich, P. S. Maynard, and H. J. Cossentine of Penticton; and Messrs. H. W. Corbett and W. H. King of Kaleden. The growing conditions in these orchards may be briefly described as follows.

In the Underwood orchard, soil is light and underlaid with gravel. The cover crop consisted of a mixture of alfalfa and grass forming a sod. The trees were about 20 years old, carried light green foliage, and had made short terminal growth apparently from lack of adequate supplies of nitrogen. They had produced comparatively low yields.

The Davenport orchard is located on a deep silt soil. There was a scant cover crop of alfalfa and sweet clover. The trees were about 25 years old, large, and in good vigour. Many of them had developed the biennial bearing habit, and in some trees individual branches bore heavy and light crops alternately. They had received light pruning. Serious loss from bitter pit had been experienced in previous years.

In the Lucich orchard the soil is a deep silt. A cover crop of sweet clover, vetch, and grasses was maintained, being disced once or twice a year. A 6-10-10 fertilizer had been applied twice during the previous 3 years at the rate of 5 pounds per tree. Irrigation water had been applied efficiently and in adequate amounts. The trees were about 25 years old and in good vigour. They had been well pruned. Light thinning was practised on heavily laden trees. Serious loss from bitter pit had been experienced in previous years.

The Maynard orchard is located on deep silt soil. The trees were about 28 years old, large and in good condition. Some trees had developed the biennial bearing habit, producing heavy crops one year and light the next. Others bore annually with the fruit well distributed over the bearing surface. Still others bore heavy and light crops on individual branches in the same year.

In the Cossentine orchard there is a gravel loam ridge running through an area of deep silt. The cover crop was sparse but good orchard manage-

ment had been practised, with the result that the trees were in excellent condition. They were over 20 years of age, large, and in heavy bearing, producing about 1,000 packed boxes to the acre. There was serious loss from bitter pit in 1940.

The Corbett orchard slopes towards the east. The soil is a deep gravelly loam. There was a cover crop of alfalfa and weeds. Orchard management had been good with the result that many of the 20-year-old trees carried 30 packed boxes of fruit per tree. Losses from bitter pit were serious in 1940.

In the King orchard the soil is a deep silt loam. The cover crop was sparse, due probably to the dense shade produced by the large trees. Many of the trees had developed the biennial bearing habit, but the average production per acre was high. A fertilizer experiment comparing the effects of complete fertilizer, nitrogen only, and no fertilizer had been in progress in this orchard for many years. Losses from bitter pit were serious in 1940.

Similar harvesting and storage experiments were conducted with Newtown as with Cox Orange and Northern Spy using the same general technique. Having regard to the comparatively extensive plantings of Newtown large amounts of fruit were used and the tests were replicated in several orchards.

Amount of Crop and Bitter Pit in Newtown

Fruit obtained from the Lucich orchard in 1939 and 1940 provided evidence regarding the influence of amount of crop on susceptibility of Newtown to bitter pit. These data are presented in Table 9.

TABLE 9.—AMOUNT OF CROP AND BITTER PIT IN NEWTOWN APPLES OBTAINED FROM LUCICH ORCHARD

Tree no.	Performance 1939		Performance 1940	
	Crop	Bitter pit	Crop	Bitter pit
		%		%
1	Heavy	2	Light	35
3	Heavy	2	Light	10
4	Heavy	1	Light	11
7	Heavy	14	Light	5
8	Heavy	1	Light	13
2	Light	2	Heavy	2
5	Light	4	Heavy	0
6	Light	17	Heavy	3
9	Light	1	Heavy	1
10	Light	9	Heavy	0

The figures incorporated in Table 9 indicate that in most cases the fruit from individual trees was more susceptible to bitter pit in the light crop year than in the heavy crop year. In this connection it is of interest to note that while tree No. 7 was classified as heavy crop in 1939 it produced, in both 1939 and 1940, fruit of the large angular, yellow coloured type commonly found on light crop trees.

Additional evidence concerning the susceptibility of apples from light crop trees to bitter pit was secured from fruit obtained in the Davenport, Maynard, Corbett, King and Cossentine orchards. The general procedure followed was to select 10 heavy and 10 light crop trees in each orchard and to harvest at least 2 bushel-boxes of apples at random from each of these trees. The percentages of this fruit which developed bitter pit are indicated by the figures presented in Table 10.

TABLE 10.—AMOUNT OF CROP AND BITTER PIT IN NEWTOWN APPLES FROM MAYNARD, DAVENPORT, CORBETT, KING AND COSSENTINE ORCHARDS

Orchard	Year	Average bitter pit in trees carrying		
		Heavy crop	Light crop	Medium crop
		%	%	%
Davenport	1939	1	6	—
Maynard	1940	3	20	—
	1941	1	12	—
	1942	0	20	1
Corbett	1941	0	8	—
	1942	0	5	2
King	1941	0	0	—
	1942	0	1	2
Cossentine	1941	0	0	—
	1942	0	3	1

It will be noted from the data presented in Table 10 that regardless of orchard or year of harvest there was a consistent tendency for the fruit from light crop trees to develop more bitter pit than that from heavy crop

FIGURE 5. Bitter pit in Newtown.

trees. On the other hand in the fruit from the King and Cossentine orchards in both 1941 and 1942 very little bitter pit developed even in the fruit from light crop trees.

In 1942 ten trees carrying about half a full crop were selected in each of the Maynard, Corbett, King and Cossentine orchards. As indicated by data presented in Table 10 a comparatively small percentage of these apples from medium crop trees developed bitter pit.

Date of Picking and Bitter Pit in Newtown

The results obtained with date of picking experiments conducted in the Lucich and Maynard orchards in 1940 are indicative of the influence of maturity at harvest time on susceptibility of Newtown to bitter pit. These results are presented in Table 11. Each figure indicates the percentage of bitter pit which developed in over 400 apples picked from a group of 5 heavy or light crop trees.

TABLE 11.—DATE OF PICKING AND BITTER PIT IN NEWTOWN APPLES OBTAINED FROM LUCICH AND MAYNARD ORCHARDS 1940

Orchard	Crop	Bitter pit in fruit from each picking				
		Sept. 23	Sept. 30	Oct. 7	Oct. 15	Oct. 21
		%	%	%	%	%
Lucich	Heavy	0	4	1	0	0
Lucich	Light	29	22	14	6	7
Maynard	Heavy	1	4	3	1	0
Maynard	Light	23	32	31	8	10

It will be noted that in the fruit from the light crop trees in both orchards there was more bitter pit in the early than in the late pickings. In the fruit from the heavy crop trees there was very little bitter pit regardless of picking date. Similar results were secured in 1941 and 1942 with fruit from the Maynard and Corbett orchards, but very little bitter pit developed in the fruit from the King and Cossentine orchards even when picked early in the season from light crop trees.

Date of Picking and Brown Core in Newtown

Newtowns as grown in British Columbia are seldom affected with the type of internal breakdown frequently found in the Jonathan, Cox Orange, and Northern Spy varieties. However, another type of internal injury known as brown core or core flush does occur quite often in Newtowns. This disorder is characterized by a light brown discoloration within the core line. It is seldom evident before January and increases in severity as the storage season progresses. When fruit is removed from cold storage to a ripening room, brown core usually increases in severity for a period of about two weeks. While fruit affected with brown core remains firm and edible it usually takes on a rather unpleasant aldehyde flavour.

Susceptibility of Newtown to brown core is influenced by date of picking. Evidence supporting this statement was obtained from date of picking experiments conducted in the Lucich orchard in 1940 and the King

orchard in 1941. After being held in 32° F. storage for 6 months and in a 60° F. ripening room for 2 weeks, the apples were cut to determine development of brown core. The results recorded are reported in Table 12.

TABLE 12.—DATE OF PICKING AND BROWN CORE IN NEWTOWN APPLES OBTAINED FROM THE LUCICH ORCHARD IN 1940 AND THE KING ORCHARD IN 1941

Orchard	Crop	Brown core in fruit from each picking				
		Sept. 23	Sept. 30	Oct. 7	Oct. 15	Oct. 21
		%	%	%	%	%
Lucich	Heavy	19	18	7	3	3
Lucich	Light	44	33	27	18	14
King	Heavy	63	64	67	13	34
King	Light	68	71	71	62	54

It will be noted that fruit from the later pickings was somewhat less susceptible to brown core than was fruit from the early pickings. Thus harvesting of Newtowns in an immature condition tended to render them subject to brown core as well as bitter pit. The unusually severe development of brown core in the 1941 crop may have been due in large measure to the cool wet weather experienced that autumn.

Maturity Indices for Newtown

Harvest records on Newtown apples indicate that the seed colour changes to dark brown several weeks before the fruit is ready to pick. Changes in hardness have not proved sufficiently great or consistent to be of value as a maturity test. Skin colour and flesh colour were observed to turn from green to yellowish tints much earlier on light crop than on heavy crop fruits. In fact the fruit on heavily loaded trees was often quite green in colour when ready to pick. On the other hand the iodine test revealed that the starch disappeared from the flesh of light crop fruits less rapidly and consistently than from that of heavy crop fruits.

When used on fruits from trees carrying a full crop the iodine test proved a very satisfactory index of maturity. Fruit picked when the core area contained starch tended to be poor in quality and more subject to bitter pit, scald, brown core and shrivelling than that picked when the core was free of starch. Fruit left on the tree until starch disappearance from the flesh had produced a definite mottled effect, developed good quality and was resistant to storage troubles, but practical considerations necessitate commencement of picking before this stage is reached. The range of starch-iodine reaction in fruit from heavy crop trees picked on September 23, September 30 and October 21, 1940, is shown in Figure 6.

While maturity was influenced somewhat by seasonal weather conditions, Newtowns were seldom ready to harvest before October 1, and quality was improved by harvesting 1 or 2 weeks later. In this connection, however, growers have learned from experience that danger of loss from frost makes it desirable to have the entire crop off the trees by October 20.

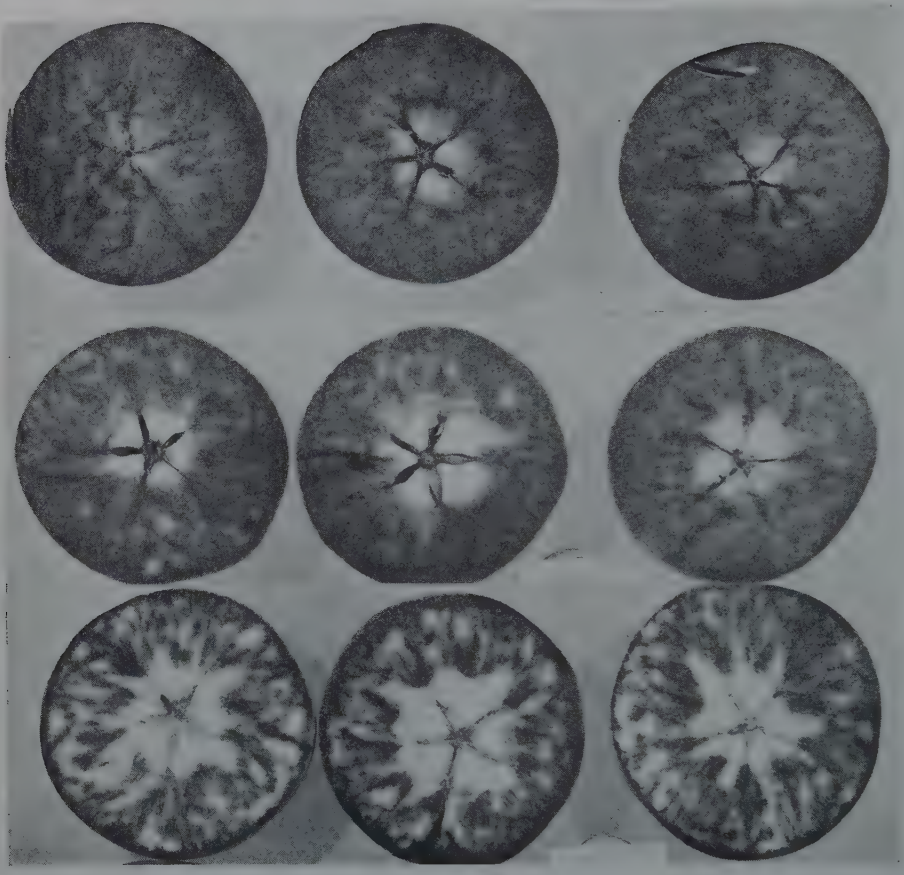

FIGURE 6. Starch-iodine reaction in Newtown picked from heavy crop trees in 1940. Top row picked September 23, centre row September 30, bottom row October 21. Specimens in centre row illustrate reaction at satisfactory maturity.

Storage Treatment and Bitter Pit in Newtown

The effect of storage treatment on development of bitter pit in Newtown is exemplified by the results obtained from an experiment conducted with apples from the Lucich and Maynard orchards in 1940. Sufficient fruit was picked on September 23 from each of 10 trees in each orchard to provide 1 bushel-box of apples from each tree for each of the 5 storage treatments indicated in Table 13, and examined for bitter pit in December, January, and March. There was no significant increase in bitter pit development after the December examination. The amount of pit which developed under each storage treatment is shown in Table 13.

The data presented in Table 13 indicate that prompt storage at 32° F. brought about a slight reduction in the amount of bitter pit which developed in susceptible fruit.

TABLE 13.—STORAGE TREATMENT AND BITTER PIT IN NEWTOWN APPLES OBTAINED FROM LUCICH AND MAYNARD ORCHARDS, SEPTEMBER 23, 1940

Storage treatment Relative humidity 85	Bitter pit after 5 months' storage			
	Lucich orchard		Maynard orchard	
	Heavy crop	Light crop	Heavy crop	Light crop
Temp.	%	%	%	%
60° F. within 24 hours	3	47	6	50
40° F. within 24 hours	4	30	5	51
32° F. within 24 hours	0	29	1	24
32° F. after 1 week at 60° F.	1	42	1	34
32° F. after 3 weeks at 60° F.	7	40	3	47

Seasonal Weather Conditions and Bitter Pit

Records extending over a period of years indicate that serious losses from bitter pit have been practically an annual occurrence with Okanagan-grown Cox Orange, and Northern Spy, averaging about 20% of the total tonnage of these varieties. Cullage records and observations of packing house managers in Naramata, Penticton and Kaleden indicate that bitter pit losses have been serious in Newtown in 4 out of the past 6 years, averaging about 5% of the tonnage in these districts. Losses were especially heavy in 1940 and comparatively light in 1941 and 1942. These observations suggest that seasonal weather conditions exert an important influence on the susceptibility of Newtown apples to bitter pit.

In the hope of revealing a definite correlation between weather conditions and the prevalence of bitter pit, a careful comparison was made of sunshine, rainfall, and temperature conditions which prevailed at the Summerland Experimental Station during the growing seasons of 1939, 1940, 1941, and 1942. Some of the data are shown in Table 14.

TABLE 14.—SEASONAL WEATHER CONDITIONS AND BITTER PIT

Weather conditions	Severe bitter pit		Slight bitter pit		
	1939	1940	1941	1942	26 yr. av.
Hours sunshine Aug. and Sept.	557	509	365	559	479
Hours sunshine April to Oct.	1658	1653	1432	1565	1636
Inches rain Aug. and Sept.	0.7	1.0	4.1	0.2	1.5
Inches rain April to Oct.	4.2	6.4	12.5	8.2	8.1
Mean temp. Aug. and Sept.	68.2	66.9	62.1	66.2	63.8

From the data presented in Table 14 it will be noted that during 1939 and 1940, two years when bitter pit was prevalent, there was more than the average amount of sunshine in August and September and also in the period April to October inclusive; whereas in 1941 and 1942, two years when bitter pit caused little loss in Newtown, sunshine for the period April to October was significantly below average. Furthermore rainfall during the growing season was markedly lower in 1939 and 1940 than it was in 1941 and 1942.

On the other hand weather conditions during August and September were very different in 1942 from what they were in 1941. During these months sunshine was below average in 1941 and above average in 1942. Conversely rainfall during August and September was unusually heavy in 1941 and unusually light in 1942. Mean temperatures for August and September were above average in 1939 and 1940 but this was also the case in 1942.

These data serve to indicate the complexity of the problem, and the need for accurate records extending over a longer period of years before making any attempt to predict whether losses from bitter pit are likely to be heavy or light in any particular year.

DISCUSSION

The fact that heavy losses have frequently been experienced from bitter pit in Cox Orange grown in the Okanagan Valley suggests that the environmental conditions responsible for the trouble in this variety involve climate or some other factor common to the district as a whole. Similarly the growing conditions prevalent in the Okanagan have made bitter pit almost an annual problem with the Northern Spy variety. On the other hand, with Newtown, losses from bitter pit have varied greatly from orchard to orchard and season to season.

With all three varieties studied; namely, Cox Orange, Northern Spy, and Newtown, the results obtained in these investigations indicate that losses from bitter pit can be materially reduced, but not entirely prevented, by picking the fruit at the proper stage of maturity. Similarly the evidence indicates that a slight reduction in losses from bitter pit can be secured by storing the fruit promptly at 32° F. Nevertheless, the data obtained reveal that regardless of harvesting procedure and storage treatment, the fruit from trees carrying less than a third of a full crop is likely to develop bitter pit. This light crop fruit constitutes only a small percentage of the total crop, yet when mixed with the main tonnage may necessitate costly repacking or even payment of claims after shipment to market. Accordingly, there are good reasons for segregating the fruit from light and heavy crop trees. The apples on light crop trees average larger than those produced by heavy crop trees, but appreciable quantities of small apples are produced even on light crop trees. Thus the regular packing house procedure of grading for size does place much of the fruit from light crop trees in the large size groups, which can then be sold for processing. Nevertheless, packing house grading distributes the small sizes from light crop trees amongst the bulk of the tonnage from heavy crop trees necessitating repacking in seasons when bitter pit is prevalent.

Grading for colour has been suggested as a simple and effective means of separating the fruit from light and heavy crop Newtown trees after it reaches the packing house. In this connection it is true that the fruit from light crop trees is usually yellow in colour. In addition light crop fruit is longer and more angular in shape than that from very heavy crop trees. However, annual bearing trees carrying quite good crops usually produce fruit intermediate in colour between green and yellow. Thus grading for yellow colour, while desirable from the standpoint of producing a uniform

appearing pack, would group together the small quantities of pit-susceptible fruit from light crop trees and comparatively large quantities of somewhat similar coloured but pit-resistant fruit from trees carrying medium crops.

Accordingly, the logical place to segregate the fruit from light-crop trees is in the orchard at harvest time. The chief difficulty involved in segregating fruit from light crop trees lies in deciding which trees should be included in the light crop classification. Some trees have been observed on which individual branches alternate in bearing, one part of a tree carrying a heavy crop in the same year that other branches carry a light crop. On such trees the fruit from the heavy crop branches usually behaves like that from heavy crop trees. As a general rule, fruit from trees carrying less than a third of a normal crop following a heavy crop is likely to prove very susceptible to bitter pit.

Maturity indices such as seed colour, skin colour, and flesh colour suggest that apples on light crop trees mature earlier than those on heavy crop trees. On the other hand the iodine test indicates that starch disappearance takes place more slowly and less consistently from apples on light crop than from those on heavy crop trees. Furthermore, the longer light crop apples are left on the trees the less susceptible they become to bitter pit, brown core, and scald. Thus, there are good reasons for leaving the light crop trees unpicked until *after* the fruit from heavy crop trees has been harvested. However, the question as to whether it is most practical to pick the light crop trees before, after, or at the same time as the heavy crop trees depends on conditions and facilities in each individual orchard. The factor of primary importance is to make sure that the fruit from trees carrying less than a third of a crop is kept separate from the main tonnage. This light crop fruit is not only susceptible to bitter pit but also to such storage troubles as breakdown, brown core, and scald. Claims and costly repacking would be prevented by disposing of it directly to processing plants.

SUMMARY

Bitter pit as it occurs in Okanagan grown Cox Orange, Northern Spy, and Newtown, is described and illustrated. The reasons for undertaking a comprehensive investigation of the bitter pit problem in the Okanagan Valley are presented. The findings of investigators in other fruit regions of the world are briefly discussed. The scope of the investigations undertaken is outlined and the methods of procedure briefly stated.

Comprehensive harvesting and storage experiments were conducted with fruit of the Cox Orange and Northern Spy varieties over a 2-year period, and with the Newtown variety over a 5-year period. In these experiments over 1,000 bushel boxes of apples picked from over 100 individual trees located in 10 different orchards were used. The harvesting experiments involved picking fruit from lightly and heavily laden trees at weekly intervals from before until after the customary picking season. Records were made of the maturity of the fruit when harvested and the amount of pit which subsequently developed in the specimens from each

tree. In the storage experiments the fruit was subjected to various temperature and humidity conditions. Careful records were made of the orchard environment and amount of crop carried by all trees from which fruit was obtained for harvesting and storage experiments.

The more important results recorded may be briefly stated as follows:

1. Fruit from trees carrying less than a third of a full crop was much more susceptible to bitter pit than was fruit from trees carrying more than a third of a full load.

2. Harvesting at desirable maturity as indicated by maturity tests materially reduced, but did not entirely prevent, the development of bitter pit.

3. Prompt storage at 32° F. delayed and had a slight tendency to reduce development of bitter pit.

4. After storage at 32° F. for 2 months most of the affected specimens had reached the stage at which the pitting could be readily discerned on the exterior of the fruit.

5. Seasonal weather conditions exerted an important influence on development of bitter pit in the Newtown variety which proved very susceptible to the disorder from 1937 to 1940 but quite resistant in 1941 and 1942.

The practicability of control measures based on the above findings is discussed.

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STUDIES IN SEED POTATO TREATMENTS. TESTING AND ADJUSTING CORROSIVE SUBLIMATE SOLUTIONS

I. LABORATORY CONTROL METHOD[1]

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In 1935, the need of a practical test, by potato growers, for checking the strength of bi-chloride of mercury solutions, was drawn to the attention of the Dominion Agricultural Chemist by the Dominion Botanist, in response to an urgent request from the Plant Pathologist, Dominion Laboratory of Plant Pathology, Charlottetown, P.E.I. The authors of this paper, at that time, succeeded in developing a suitable field test, which is published in the succeeding paper (5). The application of the laboratory and field methods might well be used to advantage, especially at this time and during the post war period, to increase potato production.

Exhaustive laboratory attempts were made to develop a simple colorimetric test by the use of test papers. Stannous chloride (16, 13), potassium iodide (7), cuprous iodide (1), cadmium sulphide, zinc sulphide, zinc purpurate (4), diphenglcarbazide (8, 12) and other reagents were used to prepare test papers. Test papers proved unsuccessful. The colour intensities failed to differentiate quantitatively the mercuric chloride solutions between 1 : 1000 and 0.5 : 1000.

A method was sought that would not be too complicated but accurate enough for both laboratory and field use. Jamieson's (6) appeared to be the most reliable of the laboratory methods (2, 10, 17, 3, 11, 14), but Walker's (15) showed possibilities of adaptations for both laboratory and field control. According to Walker's test, the partially exhausted mercuric chloride solution was added to a measured volume of a test solution, containing 5 grams of potassium iodide and "a very little" copper sulphate per 1000 mls. water, until a uniform red cloudiness was produced. The total volume, in a specially prepared measuring glass, coincided with the required amount of corrosive sublimate needed to adjust the treatment solution to its effective concentration, viz. 1 : 1000.

EXPERIMENTAL

To overcome the difficulty experienced in duplicating the end point, an improved form of Walker's field test was first worked out for laboratory use and later adapted to field control (5). A definite weight of copper sulphate was employed and on account of the presence of free iodine in the test solution-mixture, the introduction of a weak starch solution was found advantageous. Standard test solutions were prepared and titrated against

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standard mercuric chloride solutions: for test solutions, the concentration of potassium iodide was maintained at 5 grams per litre but the pentahydrate of copper sulphate was varied from 0.1 to 1.0 gm. per litre in the various mixtures; the mercuric chloride solutions were varied from 0.5 to 1.0 gm. per litre.

A mixture of 5 grams potassium iodide and 0.5 gram copper sulphate pentahydrate per litre was selected as the most suitable test solution, having an iodine concentration of 0.2679 gm. per litre (0.0021N). The iodine was determined by sodium thiosulphate titration (by adding 10 ml. 30% KI solution) and agreed with the theoretical concentration from the equation:

$$2CuSO_4 + 4KI = I_2 + 2CuI + 2K_2SO_4$$

according to Mellor (9), viz., 0.2541 gm. per litre (0.0020 N). Ten ml. of 0.2% filtered starch solution was found the most suitable to add to 50 or 100 ml. of mercuric chloride solution.

In the laboratory test, the standard potassium iodide—copper sulphate solution is run into the corrosive sublimate solution of unknown strength. In the field (5), the titration is reversed because the simplest form of apparatus was essential. Chemically pure mercuric chloride solution, 0.8 gm. per litre, was employed to standardize the test solution. The preparation of solutions and procedure for the laboratory test follow in detail.

LABORATORY CONTROL METHOD

Reagents

(1) Standard test solution containing a mixture of 5 grams of potassium iodide (KI) and 0.5 gm. copper sulphate pentahydrate ($CuSO_4 . 5H_2O$) per litre. Accurately weigh each chemical and dissolve separately in about 100 ml. water. Transfer the solutions quantitatively to the same litre volumetric flask, make up to mark, mix thoroughly and filter into brown coloured bottle. If care is exercised, the clear yellow supernatant liquid can be used without filtering. One ml. equals 0.00396 gram mercuric chloride.

(2) Starch solution 0.2%. Mix into a paste 2 grams starch with 5 ml. water. Pour into a litre of boiling water. Stir vigorously and boil 2 minutes. Stir in a few powdered crystals of mercuric iodide, as a preservative, and allow to filter into a bottle overnight. A few added crystals of mercuric chloride will prevent the starch solution from becoming mouldy and unfit for use.

Procedure

Collect about 350 ml. of "corrosive sublimate treatment solution to be tested" in a glass container and filter if dirty. Transfer 100 ml. of the clear treatment solution to a 300 ml. erlenmeyer flask. Run in rapidly the yellow standard test solution from a burette down along the inside of the flask until a yellowish or orange turbidity occurs. Mix by rotatory motion and add 10 ml. of 0.2% starch solution. Continue the titration. As the end point is approached, the blue coloration, which is formed at the surface from each additional drop, will disappear less rapidly with constant mixing. Proceed cautiously until the silky yellow or orange turbidity assumes a bluish, greenish or purplish tinge. The last drop, which produces the

first perceptible bluish tinge, constitutes the end point of the titration. Burette reading $\times$ 0.00396 $\times$ 10 equals gram mercuric chloride per *1000 ml.* of treatment solution. The burette reading is also used in the respective formulae or referred to the table to obtain the amount of 5% "stock" necessary to adjust 5 litres or 5 gallons corrosive sublimate solution to 1 : 1000.

PREPARATION AND ADJUSTMENT OF TREATMENT SOLUTIONS TO 1 PART MERCURIC CHLORIDE PER 1000.

The original treatment solution and subsequent adjustments, required after successive seed batch treatments, should be made from a 5% "stock" solution which has been carefully prepared in hot water. It is very difficult to dissolve corrosive sublimate powder in cold water. In the laboratory 5 litres or 5 gallons treatment solution may be employed, instead of the 25 gallon field basis. The solutions are prepared and adjusted as follows.

"Stock" Mercuric Chloride Solutions—5%

Dissolve 50 grams of the powder in 1000 ml. of hot water in a glass beaker. If stored in glass bottles for any length of time, it should be tested before using. The test can easily be made by diluting 5 ml. of "stock" to 250 ml. The mercuric chloride can then be determined from 100 ml. of the diluted solution and the "stock" labelled accordingly.

(1) *On the 5-litre Basis*

Add 100 ml. of 5% "stock" to 4900 ml. water in a suitable vessel, enamelware free from chipped surfaces, glass or wooden. Mix well by stirring with a wooden stick or glass rod. Mark the 5-litre volume by inserting a stick or glass rod vertically and cutting a notch or scratch at the 5 litre level. Before treatment, the seed tubers are washed free from adhering soil by soaking for 5 to 10 hours in clean water. While still moist, the washed potatoes are immersed in a 1 : 1000 treating solution for $1\frac{1}{2}$ hours. After each batch treatment, when the potatoes have been removed from the solution, water must be added to the original volume and mixed thoroughly. The strength of the used corrosive sublimate solution is then determined according to the test procedure and the "stock" required to be added is obtained from the "adjustment Table" or calculated from the following formula:

$$\frac{5 - (0.198 \times \text{Burette reading})}{0.05} = \text{Ml. of "stock" to add per 5 litres treatment solution}$$

5 = grams mercuric chloride per 5 litres original solution (1 : 1000).

Burette reading = ml. test solution titrated against 100 ml. of partially exhausted solution.

0.198 = 0.00396 $\times$ 50 (One ml. test solution is equivalent to 0.00396 gm. mercuric chloride).

0.198 $\times$ Burette reading = grams mercuric chloride per 5 litres of partially exhausted treatment solution.

0.05 = gram weight mercuric chloride per ml. "stock".

Example: The titration of 100 ml. of used treatment solution required 20.70 ml. of test solution. The strength of the treatment solution was 0.82 gms. mercuric chloride per 1000 and therefore requires 18 ml. "stock" to adjust 5 litres of treating solution.

The added "stock" requirement must be thoroughly mixed to restore the treatment solution to its effective concentration of mercuric chloride, 1 : 1000. The testing and adjusting procedures follow each batch treatment.

(2) *On the 5-gallon Basis (1 gallon = 4546 m.)*

Measure 5 gallons water into a suitable wooden or enamelware vessel and mark the level for 5 gallon capacity. (A stick may be conveniently used by inserting it vertically and cutting a notch at the 5 gallon level.) Withdraw 455 ml. of water, add 455 ml. "stock" and mix the solution thoroughly. After soaking for $1\frac{1}{2}$ hours, remove the potatoes and add water to the 5-gallon mark. Determine the strength of the used solution according to the titration procedure. Obtain the "stock" requirement for adjustment from the table or the following formula:

$$\frac{22.730 - (0.9 \times \text{Burette Reading})}{0.05} = \text{ml. "stock" to add per 5 gallons used treatment solution}$$

Add and mix the "stock" requirement. The strength of the corrosive sublimate solution has been restored to 1 : 1000 and is ready for the next batch treatment.

(3) *Bases for 25 litres or 25 gallons*

For preparation and adjustment of 25 litres or 25 gallons of treatment solution, the quantity of "stock" required would be 5 times more than for 5 litres and 5 gallons, respectively. New adjustment tables can readily be compiled for any treatment-capacity-basis by multiplying by the desired factor.

Adjustment Table

The following reference table has been compiled to facilitate adjustments. The burette reading gives the volume of standard test solution equivalent ot the 100 ml. sample corrosive sublimate treatment solution. The corresponding "stock" requirement for adjusting 5 litres or 5 gallons of treatment solution is found in column 3 or 4, respectively. For example, the titration of 100 ml. of treatment solution gave a burette reading of 22.45 ml. of standard test solution; for the 5-litre treatment, 11 ml. "stock" are required; for the 5-gallon treatment, 50.5 ml. "stock" are required. The corresponding strength is 0.89 gm. mercuric chloride per 1000 ml. solution.

SUMMARY

A simple control test was developed which may be used to check the concentration of mercuric chloride solutions at the initial and successive seed potato batch treatments for the purpose of adjusting the solutions to the effective strength to ensure successful treatments. An aliquot of 100 ml. of the corrosive sublimate treatment solution, between 1 : 1000 and 0.5 :

1000, in the presence of a weak starch solution, is titrated against a test solution containing 5 grams potassium iodide and 0.5 gram copper sulphate pentahydrate until a blue colour appears. The titration result is referred to a formula or table to obtain the amount of 5% stock corrosive sublimate solution required to adjust the treatment solution to 1 : 1000 on a 5-litre or 5-gallon solution basis or multiples thereof.

ADJUSTMENT TABLE

Strength of treatment solution in parts $HgCl_2$ per 1000	Burette reading Ml. test solution	Mls. of 5% "stock" Corrosive sublimate required to adjust solution to 1 : 1000	
		5 litres	5 gallons
1.00	25.25	None	None
0.99	25.00	1	4.6
.98	24.75	2	9.1
.97	24.50	3	13.6
.96	24.25	4	18.1
.95	24.00	5	22.6
.94	23.75	6	27.1
.93	23.50	7	31.6
.92	23.25	8	36.1
.91	23.00	9	40.6
.90	22.75	10	45.1
.89	22.45	11	50.5
.88	22.20	12	55.0
.87	21.95	13	59.5
.86	21.70	14	64.0
.85	21.45	15	68.5
.84	21.20	16	73.0
.83	20.95	17	77.5
.82	20.70	18	82.0
.81	20.45	19	86.5
.80	20.20	20	91.0
.79	19.95	21	95.5
.78	19.70	22	100.0
.77	19.45	23	104.5
.76	19.20	24	109.0
.75	18.95	25	113.5
.74	18.70	26	118.0
.73	18.45	27	122.5
.72	18.20	28	127.0
.71	17.95	29	131.5
.70	17.70	30	136.0

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STUDIES IN SEED POTATO TREATMENTS.
TESTING AND ADJUSTING CORROSIVE SUBLIMATE SOLUTIONS
II. FIELD CONTROL METHOD[1]

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This control method was originally developed for the Dominion Botanist for use of the Dominion Laboratory of Plant Pathology, P.E.I., in 1935. It is published now as a contribution to the war effort toward increased potato production. Prior to 1933, Walker (7) used a modification of this method successfully for three years. The preceding paper (3) of this journal was used as the basis for developing the method in its present form.

Seed treatment (6) has become a necessity for controlling rhizoctonia, scab (5) and black leg (4), tuber borne diseases. Corrosive sublimate is more effective than formaldehyde in destroying rhizoctonia sclerotia and although less effective for controlling scab, it is preferred, because neither can be depended upon for scab control in scab-infested soil (6, 1, 2).

Unfortunately, many seed treatments are ineffective, and labour and materials are wasted, because the average farmer has not had the training to appreciate the numerous agencies which may cause deterioration of mercuric chloride solutions. Unpublished investigations carried on in this laboratory have shown that the potato grower cannot exercise too much care in the preparation and handling of corrosive sublimate solutions. Mercuric chloride solutions are rapidly reduced to metallic mercury by metals of any kind, by soil, vegetable matter and roots adhering to potatoes, by sacks, by hampers or crates, by the potatoes themselves, etc. (8). However, the authors believe that with proper instruction and demonstration the average farmer can use this field control test to advantage.

PRECAUTIONS

Successful corrosive sublimate treatment depends mainly on how strictly the following precautions are practised.

Before treating, remove as much soil as possible by soaking the tubers in clean water for 5 or 6 hours.

Prepare "stock" from corrosive sublimate powder and hot water in enamelware (free from chipped surfaces), glass or wooden vessels. Store in gallon bottle or quart sealers, stopper well and label "POISON".

Do not use tin or aluminum funnels.

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[2] Formerly Junior Chemist, Division of Chemistry, Central Experimental Farm, Ottawa (1934–36 incl.). Now Assistant Agricultural Scientist, Tobacco Division, Central Experimental Farm, Ottawa.

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Use "stock" to prepare and adjust treatment solutions in a suitable concrete or wooden container for holding 25 gallons of water and 3 to 4 bushels of potatoes.

Never allow metal of any kind to come in contact with corrosive sublimate solutions.

Never treat seed in wooden crates or hampers (which are held together by nails), or in gunny or grain sacks.

ALWAYS USE THE IMPERIAL FLUID MEASURE IN TESTING AND ADJUSTING TREATMENT SOLUTIONS. Both the large Inperial and the small U.S. sealers, etc., are used in farm kitchens. The U.S. fluid measures are only $\frac{4}{5}$ of the Imperial capacities as follows:

	Pint	*Quart*	*Gallon*
	oz.	oz.	oz.
Imperial or British fluid measure, ounces	20	40	160
U.S. or wine measure, ounces	16	32	128

If there is any doubt, use the "100 ml. or 100 cc. graduate" and water to check the pint measure, 570 ml. equals one Imperial pint. Likewise check the Imperial quart and gallon, remembering that 8 pints = 4 quarts = 1 gallon.

PREPARATION OF "STOCK"

The "stock" contains 8 ounces of corrosive sublimate per Imperial gallon and is prepared by dissolving the powder in hot water as follows. Heat to boiling about $\frac{3}{4}$ gallon of water in an unchipped enamelware or glass vessel. Weigh 8 ounces of the powder, as accurately as possible, and add to the water. Stir with a clean wooden stick or glass rod until completely dissolved. Allow to cool and carefully transfer to an Imperial gallon bottle. Rinse the vessel several times and add the rinsings to the full gallon capacity. Stopper, mix thoroughly by shaking, label "POISON" and set aside for use in preparing and adjusting treatment solutions.

PREPARATION OF TREATMENT SOLUTION

The common error of attempting to dissolve the powder in cold water has resulted too often in unsuccessful treatment. Corrosive sublimate is 10 times more soluble in hot water than in cold water and even with hot water considerable time and stirring are necessary. Accordingly, by using a carefully prepared "stock", there is no danger of the treatment solution being understrength at the start.

Use a clean concrete or wooden trough, oak barrel or suitable non-metallic container, large enough to hold 25 gallons of water and from 3 to 4 bushels of potatoes. Add two Imperial quarts of "stock" to 25 Imperial gallons of water. Mix thoroughly and mark the volume by inserting a clean stick vertically and cutting a notch at the solution level. Marking the volume in this manner is important for testing and adjusting the strength of the solution after each successive batch treatment.

TREATMENT OF SEED POTATOES

Before treating, wash the seed, by soaking the tubers 5 to 6 hours in clean water. Washing the tubers prevents the deteriorating effect of soil on the treatment solution and treating the tubers while still moist facilitates the killing of the rhizoctonia sclerotia. The usual procedure consists in immersing the washed tubers for $1\frac{1}{2}$ hours in the treatment solution, between 60 and 80° F. Do not immerse potatoes in gunny or grain sacks, crates or hampers, as they contribute to ineffective treatment. If desired, the treatment may be done in the fall to prevent sprout injury (2) and the treated seed stored in treated containers to prevent recontamination (5), although spring treatment may be preferred on account of the poisonous nature of the treated potatoes if eaten. After drying the treated seed on a clean floor or in crates and before cutting and planting, expose the tubers to light and air to facilitate the growth of thick stubby sprouts. Cutting knives should be dipped into 5% formaldehyde or fresh corrosive sublimate solution after cutting a diseased tuber.

APPARATUS REQUIRED

1. One "100 ml. graduated cylinder", obtainable from a Laboratory Supply Company at about 50 c. each (10% discount allowed on an order of 12 or more). Central Scientific Co. of Canada, 119 York Street, Toronto, and Canadian Laboratory Supplies, Ltd., 296 St. Paul Street, Montreal.

2. Glass or wood stirrer, 15" long and $\frac{5}{16}$" diameter with knob at one end, used for mixing solution in graduated cylinder by moving up and down.

3. Enamelware or glass vessel, gallon capacity, for preparing "stock" corrosive sublimate solution.

4. Two quart-size sealers or gallon bottle for storing "stock".

5. Imperial pint sealer for measuring "stock", marked in divisions of $\frac{1}{5}$ pint each ($\frac{1}{5}$ pint = 4 ounces = 114 ml.). Measure and pour 114 ml. water into pint container. Glue or paste a narrow strip of paper on outside of sealer from top to bottom and mark the water levels on the paper after each successive addition of 114 ml. to give a total of 570 ml., which equals 20 fluid ounces or one Imperial pint.

6. Two sealers or glass bottles, about one quart capacity, for storing the standard test solution and the starch solution.

7. Three small glass or earthenware pitchers for convenience in pouring the test solution, starch and treating solutions in the test procedure.

SOLUTIONS REQUIRED

1. Standard test solution. This must be prepared by a qualified technician in a scientific laboratory or a drug store as follows:

Carefully prepare a volumetric solution mixture of 5.0000 grams C.P. potassium iodide (KI) and 0.5000 gram C.P. copper sulphate pentahydrate ($CuSO_4 . 5H_2O$) per litre or 87.676 grains C.P. potassium iodide and 8.767 grains copper sulphate pentahydrate per Imperial quart of 40 fluid ounce capacity. Each chemical should be weighed and dissolved separately,

using 150 to 300 ml. or 5 to 10 ounces distilled water. Mix the solutions by pouring them into the measuring flask. Rinse several times and add the rinsings and water to the required volume. Mix thoroughly. Allow any precipitate to settle, filter and bottle. The yellow filtrate constitutes the test solution, 1 ml. or 1 cc. of which equals 0.00396 gram mercuric chloride. The druggist's charge should not exceed 25c. per quart nor 75c. per gallon, if the glass container is supplied.

2. Starch solution. This may be prepared in the farm kitchen from any good commercial grade of "prepared starch" used in making puddings. Mix into a semi-paste, by rotary motion, a teaspoonful of starch and two teaspoonfuls water in a cup and pour into a quart of boiling water. Stir vigorously and boil not longer than 2 minutes. Allow to cool, and bottle up ready for use. Starch solutions must be freshly prepared because after a few days they become mouldy and unfit for use. (Two grams starch per litre or 35 grains per Imperial quart are suitable quantities for laboratory preparation.)

FIELD CONTROL TEST

Stated briefly, the partially exhausted solution of corrosive sublimate is added to the blue liquid mixture of 10 ml. "test solution" and 10 ml. starch solution in a "100 ml. graduate" until the blue colour disappears. The total volume of the solution in the graduate is referred to the table, which designates the "stock" required to restore the strength of the treating solution to its effective concentration. Dirty treating solutions should be filtered, although this should not be necessary if the seed tubers are washed before treating.

Test Procedure

Transfer some of the yellow test solution and likewise starch solution into separate small clean pitchers with spouts. Carefully pour 10 ml. of the yellow "test solution" into the "100 ml. graduate". If more than 10 ml. were added, pour some out to make it exactly 10 ml., reading along the bottom of the meniscus. Now, very carefully pour in the starch solution to the 20 ml. mark. (If the 20 ml. mark was exceeded by adding too much starch, the whole mixture should be thrown out, the graduated cylinder washed and the procedure repeated, so that just 10 ml. of "test solution" and 10 ml. of starch solution have been added.)

Before testing the corrosive sublimate solution, after each seed batch treatment, it is important to add enough water to restore the original volume of the treatment solution, viz., to the 25-gallon level. Collect a small pitcher-full of treatment solution and pour cautiously into the blue solution in the "100 ml. graduate" until a yellow or orange coloured turbidity appears at the surface. Move the stirrer up and down, and continue the addition of treatment solution more slowly as the colour changes to a pale blue. Finally, add a drop at a time, moving plunger up and down until the pale blue just disappears from the last drop or two. Remove the stirrer after allowing liquid to drain from it. Record the volume of the liquid in the graduate. Refer to the table and note the required amount of "stock" to add and mix with every 25 gallons of used solution to ensure effective treatment.

Example

The volume of liquid at the test end point was 67 ml. Reading opposite 67 ml. on the table, $\frac{3}{5}$ pint of "stock" must be added and mixed. This "stock" is measured by No. 5 of "Apparatus Required" or by a fluid ounce measure. Several tests should be run for practice to ascertain the end point. If the treatment solution is poured in too rapidly, the end point may be "overshot".

The following table shows the strength of, and the "stock" requirement for adjusting, the treating solutions, which coincide with the end point volume of the test, as read in the "100 ml. graduate".

ADJUSTMENT TABLE

Strength of treating solution corresponding to test volume. Parts of corrosive sublimate per 1000 of solution	"Graduate" reading at completion of test	"Stock" corrosive sublimate solution required to adjust 25 gallons of treating solution to effective strength
	ml.	pints[2]
1.00[1]	60	None
0.95	62	$\frac{1}{5}$
0.90	64	$\frac{2}{5}$
0.85	67	$\frac{3}{5}$
0.80	70	$\frac{4}{5}$
0.75	73	1
0.70	77	$1\frac{1}{5}$
0.65	81	$1\frac{2}{5}$
0.60	86	$1\frac{3}{5}$
0.55	92	$1\frac{4}{5}$
0.50	99	2

[1] A treating solution, containing one part of mercury chloride per 1000, represents the effective strength for successful treatment.

[2] If a fluid ounce measure is available, it may be used to measure the stock. ($\frac{1}{8}$ pint = 4 fluid ounces and contains $\frac{1}{2}$ ounce of dissolved corrosive sublimate powder.)

SUMMARY

A list of precautions is outlined to enable growers to treat seed potatoes successfully with corrosive sublimate solutions. Instructions are given for the preparation of treatment solution from a 5% "stock", the seed treatment procedure, the testing and adjusting of the solutions to ensure effective control of the tuber borne diseases, viz., rhizoctonia, scab and black leg.

The test is designed for use on the farm. It consists of a simple titration by means of a 100 ml. graduate. The corrosive sublimate treating solution is added to 10 ml. of a test solution and 10 ml. of 0.2% starch solution until the blue colour disappears. The graduate reading is referred to an adjustment table to obtain the required amount of stock corrosive sublimate solution necessary to mix with every 25 gallons of solution, to correct the strength to 1 : 1000.

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GROWTH AND FEED CONSUMPTION OF BACON HOGS[1]

II. RATES OF GAIN AND FEED CONSUMPTION ACCORDING TO WEIGHT OF PIG

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A standard of growth is an essential in the evaluation of critical nutrition studies. Repeatedly this is indicated where a published minimum requirement of nutrient intake for one group of animals proves to be too low for another group having a greater rate of growth than the first.

Since there is a real correlation between the quantity of feed eaten by an animal and its live weight increase, a standard of growth is not complete without a corresponding standard of feed consumption.

Crampton (1) has published swine data from which curves for average daily gain and daily feed intake were plotted on the basis of age of pig. Live weight, however, is often a more satisfactory basis on which to classify rates of gain and feed consumption. Moreover, data from 400 hogs in studies at Macdonald College (5) yielded the following correlations:

Age and gain,	$r = 0.08$
Age and feed,	$r = 0.26$
Weight and gain,	$r = 0.75$
Weight and feed,	$r = 0.78$

which indicates that the association of gain and feed consumption with age is much less marked than with weight of pig.

Since 1939 live weights and feed consumption of all hogs on nutrition experiments at Macdonald College have been recorded biweekly. Thus suitable data became available for the calculation of rates of gain and feed consumption over comparatively short intervals of time at given live weights.

SOURCE OF DATA

The data used in this study were obtained from some 220 Yorkshire pigs on comparative feeding trials at Macdonald College. Their dams were bred at the College and were related as mother and daughter or as full or half sisters. The male pigs were castrated at approximately 4 weeks of age and weaning was completed when the pigs were 8 weeks old. Litters farrowed in both January and May are represented.

Following weaning, the pigs were confined to individual pens indoors until marketed. They were fed 3 times a day up to a weight of 110 pounds, after which the noon feeding was discontinued. The meal mixture during the first period was made up of 85% of basal feed and 15% of a protein-mineral supplement while these proportions were changed to 90 and 10% respectively in the last period.

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[1] Contribution from Nutrition Laboratory, Macdonald College (McGill University) Que. Journal Series No. 178.

[2] Assistant in Experimentation.

[3] Professor of Animal Nutrition.

The basal part of the feed mixture was composed entirely of No. 1 feed barley for all hogs except some 30 which received wheat as the basal feed. The supplement fraction was made up approximately as follows: meat meal 45%, non-oily fishmeal 15%, linseed oil meal 20%, bone char 10%, salt 5% and limestone 5%. The final rations were supplemented with 15 cc. of a 2000A and 400 D cod liver oil daily for all animals under 100 lb. in weight.

TREATMENT OF DATA

The first step in the treatment of the data was to determine average rates of gain and feed intake which were applicable to specific live weights. To accomplish this each biweekly live weight increase and feed consumption of each pig was reduced to a daily basis and the values thus obtained taken as the rates applicable to the pig's weight midway between the appropriate consecutive weighings. These mid weights were then grouped at 10-pound intervals with a range of 5 pounds on either side of the plotting point.

In treating the data as described above those for male and female pigs were compiled separately yielding a curve for each sex. Without exception the rates of gain of the male pigs were greater at all weights than those of the females. However, application of Fishers' (4) test of significance showed the probabilities to be only 1 in 10 that the observed differences were real, ($P = 0.9$).

These findings do not in any way vitiate the findings of Crampton (2, 3) that male pigs make significantly faster gains, from weaning to market weight, than do female pigs with equal daily feed intakes. The apparent contradiction lies in the fact that in Crampton's studies the age was a primary variable with total gain fixed by design, while in this study age was disregarded and weight made the basis of classification.

The differences in daily feed intake between the sexes, were also found to be statistically insignificant, ($P = 0.9$).

In the light of these findings the data for both sexes were combined yielding the values for daily gain and daily feed consumption presented in Tables 1 and 2 respectively. These data appear in graphic form in Figures 1 and 2 with the resulting curves smoothed by Fisher's (4) Summation Method of Fitting Polynomials.

TABLE 1.—AVERAGE DAILY GAIN OF YORKSHIRE PIGS FROM 30 TO 200 POUNDS LIVE WEIGHT

Weight classes	Average daily gain		Weight classes	Average daily gain	
	Observed values	3rd degree polynomial		Observed values	3rd degree polynomial
lb.	lb.	lb.	lb.	lb.	lb.
30	0.49 ± 0.16	0.50 ± 0.17	120	1.85 ± 0.38	1.77 ± 0.34
40	0.77 ± 0.21	0.78 ± 0.19	130	1.83 ± 0.30	1.79 ± 0.34
50	1.04 ± 0.19	1.02 ± 0.21	140	1.80 ± 0.37	1.80 ± 0.33
60	1.22 ± 0.25	1.22 ± 0.24	150	1.71 ± 0.30	1.80 ± 0.32
70	1.36 ± 0.26	1.38 ± 0.27	160	1.77 ± 0.28	1.80 ± 0.31
80	1.46 ± 0.32	1.51 ± 0.30	170	1.76 ± 0.34	1.79 ± 0.32
90	1.55 ± 0.30	1.61 ± 0.32	180	1.80 ± 0.36	1.79 ± 0.33
100	1.70 ± 0.29	1.69 ± 0.34	190	1.80 ± 0.34	1.79 ± 0.37
110	1.67 ± 0.38	1.74 ± 0.34	200	1.83 ± 0.45	1.80 ± 0.44

TABLE 2.—AVERAGE DAILY FEED CONSUMPTION OF YORKSHIRE PIGS FROM 30 TO 200 pounds LIVE WEIGHT

Weight Classes	Average daily feed Consumption		Weight classes	Average daily feed Consumption	
	Observed values	3rd degree polynomials		Observed values	3rd degree polynomials
lb.	lb.	lb.	lb.	lb.	lb.
30	1.74 ± 0.27	1.64 ± 0.37	120	6.37 ± 0.56	6.24 ± 0.54
40	2.30 ± 0.41	2.36 ± 0.39	130	6.64 ± 0.54	6.52 ± 0.56
50	3.04 ± 0.44	3.02 ± 0.41	140	6.69 ± 0.61	6.77 ± 0.58
60	3.64 ± 0.39	3.63 ± 0.43	150	6.94 ± 0.53	6.98 ± 0.60
70	4.16 ± 0.42	4.18 ± 0.45	160	7.07 ± 0.65	7.16 ± 0.62
80	4.60 ± 0.53	4.69 ± 0.47	170	7.28 ± 0.59	7.31 ± 0.64
90	5.11 ± 0.48	5.14 ± 0.49	180	7.40 ± 0.65	7.43 ± 0.66
100	5.61 ± 0.55	5.55 ± 0.51	190	7.60 ± 0.67	7.53 ± 0.68
110	5.90 ± 0.65	5.92 ± 0.53	200	7.59 ± 0.69	7.60 ± 0.70

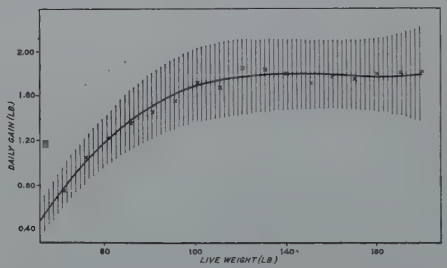

FIGURE 1. Average daily gain of Yorkshire pigs from 30 to 200 pounds live weight. Shaded area marks limits of ± one standard deviation.

It will be noted that the rate of gain per day increases rapidly from weaning until the pig reaches 120 pounds live weight after which it remains constant. Rates of gain as high as 2 pounds per day are not to be expected until pigs reach 100 pounds. Even then only a small proportion of them are likely to exceed this rate as indicated by the upper limits of the shaded area in Figure 2 above which lies only one-sixth of the population.

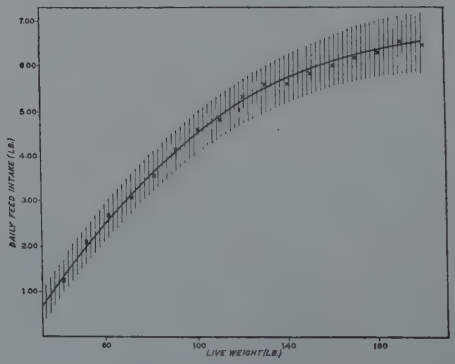

FIGURE 2. Average daily feed intake of Yorkshire pigs from 30 to 200 pounds live weight. Shaded area marks limits of ± one standard deviation.

The curve for feed consumption in Figure 2 does not show the sudden break in its curvature as in the case for gain, but rather continues its upward trend quite consistently up to the 200 pound weight. Such relations between the two curves mean only one thing of course, a decreasing efficiency in feed utilization with increasing weight of the pig. This trend of feed efficiency is indicated in Figure 3.

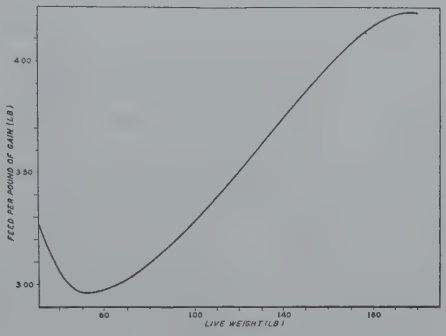

FIGURE 3. Feed required for each pound of gain of Yorkshire pigs from 30 to 300 pounds live weight.

From this graph it is apparent that the feed required for each period of gain increases from about 3 pounds for newly weaned pigs to something over 4 pounds for finished market hogs.

SUMMARY

Data are presented indicating average daily live weight increases and feed consumption for Canadian Yorkshire pigs at various live weights from weaning to 200 pounds.

The rate of gain increased rapidly until the pigs reached approximately 120 pounds in weight whence it remained stationary at an average value of 1.80 pounds throughout the remainder of the feeding period.

The apparent increase in the amount of feed required per pound of gain with increasing size of pig was approximately one pound from weaning to market weights.

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AN EXPERIMENT WITH HIGH CONCENTRATIONS OF LUBRICATING OIL SPRAYS[1]

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When lubricating oil sprays were first recommended by the Dominion Division of Entomology for pear psylla control in Ontario there was a very definite fear that annual dormant applications of 3% oil emulsion would sooner or later result in serious injury to pear trees. In view of this, in 1926, an experiment with high concentrations of oil was commenced at Vineland Station, Ontario, in order to ascertain what type or types of injury oils might cause and also to secure information regarding the margin of safety there is in using oil emulsions.

The same pear trees were sprayed each spring *when the buds were dormant* with 10 and 20% oil emulsions for a period of 15 years—three Anjou trees with 20% and 1 Anjou and 2 Bartletts with 10%. Cheap lubricating oils (viscosity 170–220 Saybolt; gravity at 60° F., 24–26 A.P.I.) were used and were emulsified with Bordeaux mixture (2 oz. copper sulphate, 2 oz. hydrated lime per gallon of oil). No spraying was done when the temperatures were near, at, or below freezing.

The 15 annual sprays of the 10% concentration caused no noticeable injury to the trees. Each season there was a retardation in leaf bud development, always very slight except in 1936, when the leaf buds were distinctly slow in developing compared with the checks. The trees sprayed with the 20% oil emulsion for 15 consecutive years suffered no fatal or permanent injury. For the first 2 seasons no injury whatsoever was observed, but in 1928, following a severe psylla infestation which had its genesis on neighbouring unsprayed trees, a considerable number of leaf buds were killed. By 1935 dead wood was noted in the lower parts of the trees, but the amount then and in any subsequent year was negligible. Each season there was a retardation of leaf bud development to a marked degree, and of blossom bud growth to a slight extent. There was a conspicuous scarcity or absence of blossoms in the lower parts of the trees, but the upper and outer portions of the sprayed trees generally carried each season as much bloom as the unsprayed neighbouring trees. As described elsewhere[4], the lenticels on young wood were greatly enlarged due to the abnormal growth of sub-lenticular tissue. The oil also caused some flaking of the phellem which, particularly in the 3-year-old wood, gave rise to what may be termed pseudo-lenticels. The enlarged lenticels and the flaking of the phellem may be considered a form of oil injury, but it was so superficial that it had no noticeable effect on the health of the trees.

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[4] The status of lubricating oil sprays in Ontario. Rept. Ent. Soc. Ont. pp. 49–57. 1931.

From 1941 to the present year (1943), the experimental trees have not been oil-sprayed, and during this period they have shown no departure from the normal in bud development or in any other respect. At the present time of writing, they have an excellent crop of blossoms and the only evidence they show of the somewhat drastic treatment to which they were subjected is their very dark and rough bark.

This experiment has clearly demonstrated that pear trees under the climatic conditions obtaining in the Niagara Peninsula are very resistant to injury from oil sprays of the type used in Ontario for pear psylla control. Fifteen consecutive applications of an oil emulsion $3\frac{1}{3}$ times the recommended strength caused no commercial loss or damage, and the same number of applications of oil 7 times the recommended strength produced no fatal or permanent injury.

It has been stated that freezing temperatures following oil applications are likely to injure dormant trees. This has not been our experience. Freezing temperatures following applications of the high concentrations of oil were experienced every season from 1926 to 1940 inclusive. As shown in Table 1, in 7 of the 15 years temperatures dropped to 25° F. or lower, and in 1940 to 17.8° F. after the sprays were applied.

TABLE 1.

Year	Date sprays applied	Lowest temp. after spraying	Year	Date sprays applied	Lowest temp. after spraying
		°F.			°F.
1926	April 23–24	32	1934	April 4	27
1927	Mar. 29	28	1935	April 2	24
1928	April 16	28	1936	April 9	30
1929	Mar. 27	23	1937	April 2	31
1930	April 4	25	1938	Mar. 23	24.4
1931	Mar. 27	28	1939	Mar. 24	24.3
1932	April 5	25	1940	April 1	17.8
1933	April 3	29			

Effect of a Light Fuel Oil on Pear Trees

At the outset of the experiment with high concentrations of lubricating oil and for 2 years, other pear trees were sprayed during the dormant season with high concentrations of semi-diesel fuel oil (viscosity 40?). In 1926, a 20% concentration destroyed most of the leaf and fruit buds, however the trees recovered; a 15% spray killed a small percentage of the buds, but 10% caused no apparent damage, The following year 10 and 15% emulsions, the only concentrations used, were responsible for no injury.

SUMMARY

Fifteen consecutive annual applications of a 10% lubricating oil spray (viscosity 170-220), applied in March or April when the buds were dormant, caused no commercial damage to pear trees, and the same number of applications of a 20% concentration produced no fatal or permanent injury.

BOOK REVIEWS

POTASH IN NORTH AMERICA. By J. W. Turrentine, Ph.D., President American Potash Institute. American Chemical Society Monograph Series No. 91; 183 pages, illustrated. Published by Reinhold Publishing Corporation, New York, 1943. Price $3.50.

This reviewer considers this book a most timely, interesting, and valuable contribution to a better knowledge and appreciation of the importance of the potash industry to agriculture and the chemical industries in North America.

The author, formerly in charge of potash investigations for the United States Department of Agriculture and latterly as President of the American Potash Institute, engaged in the direction of research and educational work on the utilization of potash, is particularly well qualified for the task which he has undertaken.

The book is divided into four chapters, with numerous topical subheadings set in excellent type. Numerous tables, charts, maps and photographs have been used to good advantage throughout the text.

In the first chapter, "Introduction: Fifteen Years in Review," the author discusses the more significant features of the developments in the potash industry in the United States, and to a more limited extent in other countries, during the period from 1926 until the present time.

Commencing with an outline of the status of the industry as it existed in 1926, an account is given of the subsequent exploratory surveys for new deposits; of the research on, and the development of, the new sources; of the organization and activities of the American Potash Institute; of the more important contributions to the literature on the developments of the industry. The concluding section of the chapter deals with a discussion of the estimated world potash reserves.

In the second chapter, "The Uses of Potash in American Industry," attention is directed first to potash in agriculture; its function in vital processes; the importance of proper ratio; signs of potash deficiency; the removal of potash by crops; and the distribution of potash materials through the medium of the mixed fertilizer industry. The second part of the chapter discusses the production of the more highly refined grades of potash and the uses of the chloride, carbonate, nitrate and chlorate of potash in the chemical industries. The concluding portion of this chapter embracing numerous tables of statistics presents an extensive discussion of the American trade in potash salts.

Chapter three, entitled "Technology of Potash Production," is the longest chapter in the book, yet the space devoted to this phase of the subject is fully justified.

Quoting extensively from the original published papers, the author has compiled in this chapter the great volume of technical information available on the processes involved in the mining, extraction, and refining of potash from the developed American deposits. Mere mention of the topical headings will suffice to indicate the scope of the discussion: the

Refining of Searles Lake Brine; the Trona Project; the Phase Rule as applied to the Trona Process; the Mining of Sylvinite; the mining of Langbeinite; the refining of Sylvinite; Flotation Methods; the Refining of Langbeinite; and the Salduro Marsh Brines.

Chapter four, "Conclusion," briefly comments on the present position with respect to domestic potash supplies; future imports from foreign sources; and the factors affecting the trend of consumption of potash in agriculture.

This book should be of interest and value to a large group of technical agriculturists, especially the soils specialists, agronomists, horticulturists, agricultural chemists and others, who are concerned with fertilizers and crop production. Manufacturers and others, in the fertilizer business, will also find it a worthwhile reference for that industry. It should also find a prominent place on the list of assigned reading for agricultural college students who are specializing in one of the fields mentioned above.

J. G. R.

THE FARMER CITIZEN AT WAR. By H. R. Tolley. The Macmillan Company, Toronto, 1943. Price $2.75.

It is a pleasure to read and to review *The Farmer Citizen at War*, by H. R. Tolley. This is by no means surprising as this author has had, in the past, and has now connection with and first hand knowledge of, the various policies and programs pertaining to agriculture in the United States for a considerable time. Both his personal reputation as an agricultural economist and his position make what he has to say on a subject of this nature necessary to all those interested in this subject. And the treatment of the subject is of such a nature as to have to-day a very wide appeal. This is because the main theme of the volume is the advantages of the democratic method either in peace or war. This would appear a very opportune time to drive this point home.

The point is driven home from start to finish of this book. From Paine's "Common Sense" to the present illustrations of the democratic method are described. The county planning boards from many widely separated parts of the country are described in detail as examples. Distinctions are drawn between the democratic and bureaucratic methods as the necessity of what the author terms "grass roots planning" is set forth as a need to secure success in farm policy. In other words the need is to make certain that people themselves share in planning policy.

The need for and the method of securing and using expert advice in meeting practical problems is exemplified by the work of the various branches of agricultural administration. It is maintained that this experience which has proved so beneficial in pre-war days may now be very valuable in the war period and will also be even more necessary in the post-war years. It may be valuable experience provided the work is carried on in a democratic rather than a bureaucratic method.

It is also suggested that the experience gained in working out farm policies may be of some assistance if and when applied to some other industries that in the past may have enjoyed more liberty in regulating

themselves. From the point of view of conservation of human as well as other resources a campaign against underconsumption is in order. The first and most important outpost to be stormed is the distribution of goods because this lags behind production techniques.

Securing of the four freedoms even in the United States is a big job, even the conservation of water, soil, and forest now needs the work of five million men for one full year. And such is only one item in the planning for the post-war period. Mention is made of the possibility of a defense program being the basis of post-war work in a comprehensive program which must be read to be appreciated.

Yet planning and action should be done, according to this author, in a democratic method. The author is none too sure that this will be the method and in this connection a criticism of another possibility set forth in *The Managerial Revolution*, by J. M. Burnham is given in Chapter VIII which is entitled "The Managerial vs. the Peoples Revolution."

The Managerial Revolution by Burnham records the inevitability of a new era in which the privileged caste will be the managers of industry. Whether these managers are employed by the government or for themselves they are destined to occupy the driver's seat in the wave of the future which is already here although recognized only by the few.

The Farmer Citizen at War is a good *antidote* or *balance* for *The Managerial Revolution*, and after reading *The Managerial Revolution* either an antidote or balance is necessary. If you agree with it you will still need the balance. On the other hand the reader not inclined to agree with it will need an antidote. And even if you belong to the probably larger group of readers who do not know what to make of it the antidote may be even more necessary.

In presenting an alternative to *The Managerial Revolution* the book here reviewed does not expect less regulation of economic affairs. The difference is in method. The author argues that anything that is wanted badly enough may be secured in a democratic way without losing any freedom.

J. E. L.